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NAS CECIL FIELD  
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REMEDIAL INVESTIGATION AND FEASIBILITY STUDY SAMPLING AND ANALYSIS PLAN  
OPERABLE UNITS 3, 4, 5 AND 6 (OU3) (OU4) (OU5) (OU6) VOLUME II NAS CECIL FIELD FL

11/1/1994  
ABB ENVIRONMENTAL

**VOLUME II**

**REMEDIAL INVESTIGATION AND FEASIBILITY STUDY**  
**SAMPLING AND ANALYSIS PLAN**

**OPERABLE UNITS 3, 4, 5, AND 6**

**NAVAL AIR STATION CECIL FIELD**  
**JACKSONVILLE, FLORIDA**

**Unit Identification Code (UIC) No. N60200**

**Contract No. N62467-89-D-0317**

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## FOREWORD

The Department of the Navy developed the Installation Restoration (IR) program to locate, identify, and remediate environmental contamination from the past disposal of hazardous materials at Navy and Marine Corps installations. The Navy's IR program follows the Department of Defense's environmental restoration program mandated by the Superfund Amendments and Reauthorization Act of 1986 to address waste sites that may pose a threat to human health or the environment.

The Navy's IR program consists of Preliminary Assessment and Site Inspection, Remedial Investigation and Feasibility Study (RI/FS), and Remedial Design and Remedial Action at sites where hazardous materials were possibly disposed. The Preliminary Assessment and Site Inspection identify the presence of pollutants. The RI/FS analyzes the nature and extent of contamination and determines the optimum remedial solution. The Remedial Design and Remedial Action complete the implementation of the solution.

Previous investigations have determined that Naval Air Station (NAS) Cecil Field has 19 sites that may pose a threat to human health or the environment. Therefore, an RI/FS will be performed at each site to address the extent and magnitude of contamination at these sites.

This document presents the workplan, sampling and analytical plan (SAP), and health and safety plan (HASP) for conducting the RI/FS for Operable Units 3, 4, 5, and 6, which include Sites 7, 8, 10, 11, 14, and 15. The workplan discusses the history and environmental setting of the sites, and presents the RI/FS rationale and scope of work. The SAP focuses on the field investigation procedures, analytical methods, and quality assurance and quality control (QA/QC) procedures. The HASP outlines the health and safety procedures for all field tasks.

Questions regarding this report should be addressed to the Commanding Officer, Code OOB, P.O. Box 111, NAS Cecil Field, Jacksonville, Florida 32215-0111.

## EXECUTIVE SUMMARY

The planning documents prepared to support the Remedial Investigation and Feasibility Study (RI/FS) activities for Operable Units (OUs) 3, 4, 5, and 6 at Naval Air Station (NAS) Cecil Field consist of the following three volumes:

- Volume I, Workplan;
- Volume II, Sampling and Analysis Plan (incorporating both the Field Sampling Plan and the Quality Assurance Project Plan); and
- Volume III, Health and Safety Plan.

Together, the three volumes present the scope of the RI/FS activities. The workplan (Volume I) describes the features of each site, provides a record of facility and site history, describes the environmental factors, details previous investigative results, provides an initial evaluation of each site, presents the RI approach, details the RI/FS tasks, and outlines the project schedule.

The sampling and analysis plan (SAP) (Volume II) focuses on the field investigative procedures, analytical methods, and quality assurance and quality control (QA/QC) procedures. The SAP provides a project description, describes site management and field methods, details the technical approach and sampling plans, and describes the QA/QC requirements for sample collection, sample handling, sample analysis, data assessment, corrective action, and reporting.

The Health and Safety Plan (HASP) (Volume III) outlines the health and safety procedures for all field tasks. The HASP includes material safety data sheets for chemicals that may be encountered at each site and provides emergency information and telephone numbers.

Volumes I through III of the RI/FS planning documents for OUs 3, 4, 5, and 6 have been prepared by CDM Federal Programs Corporation (CDM Federal) and ABB Environmental Services, Inc. (ABB-ES), under the Comprehensive Long-Term Environmental Action, Navy (CLEAN) contract (contract number N62467-89-D-0317). The format and scope of these documents are in compliance with *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S. Environmental Protection Agency [USEPA], 1988) and *Navy/Marine Corps Installation Restoration Manual* (Department of the Navy [DON], 1992), as well as other applicable USEPA and DON guidance documents.

The RI technical approach developed for each site comprising OUs 3, 4, 5, and 6 are based on several considerations including: (1) the physical characteristics and geographic location of the site, (2) the history and previous use of the site, (3) the results and conclusions of previous investigations, and (4) site reconnaissance. The primary objectives of the RI are to collect sufficient data to: characterize and quantify the nature and extent of contamination, assess potential risks to human health and the environment posed by contaminants of concern, support an FS at sources of contamination where remedial action is warranted, and support a Record of Decision (ROD) for each operable unit addressed. The FS is designed to screen and evaluate potential remedial alternatives, and to conduct treatability studies to evaluate the suitability of remedial technologies to site conditions and problems.

Note that the Base Conversion and Redevelopment Commission is developing a reuse plan for NAS Cecil Field in anticipation of the DON releasing the property. Simultaneously, the Base Realignment and Closure (BRAC) Cleanup Team (BCT) is developing a strategy to address environmental issues at the facility. The BCT strategy integrates the activities under the Installation Restoration (IR) program (including this RI/FS), with the operating compliance program and the closure compliance program. The BCT strategy supports full restoration of NAS Cecil Field. The DON is the lead agency in implementing this strategy; however, decisions regarding the BCT strategy are being made jointly by the DON, USEPA, and the Florida Department of Environmental Protection (FDEP).

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## GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
ARARs	applicable or relevant and appropriate requirements
ASTM	American Society for Testing and Materials
BCT	BRAC Cleanup Team
BHC	benzene hexachloride
bls	below land surface
BNA	base neutral acid
BRAC	Base Realignment and Closure
CDM Federal	CDM Federal Programs Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action, Navy
CLP	Contract Laboratory Program
COC	chain-of-custody
CRQL	Contract Required Quantitation Limit
DON	Department of the Navy
DOT	Department of Transportation
DQOs	data quality objectives
°C	degrees Celsius
°F	degrees Fahrenheit
ECBSOPQAM	Environmental Control Branch Standard Operating Procedures and Quality Assurance Manual
FDEP	Florida Department of Environmental Protection
FID	flame ionization detector
FOL	Field Operations Leader
FS	Feasibility Study
FSP	Field Sampling Plan
GC/MS	gas chromatograph and mass spectrometer
HASP	Health and Safety Plan
HCl	hydrochloric acid
HNO <sub>3</sub>	nitric acid
ID	inner diameter
IDW	investigative derived waste
IR	Installation Restoration
ℓ	liter
LZS	lower zone surficial
mg/kg	milligram/kilogram
ml	milliliter
mΩ/m	millimhos/meter
MS	mass spectrometer

## GLOSSARY (Continued)

$\mu\text{g}/\ell$	micrograms per liter
$\mu\text{g}/\text{kg}$	microgram/kilogram
NaOH	sodium hydroxide
NAS	Naval Air Station
NEESA	Naval Energy and Environmental Support Activity
NPL	National Priority List
NSF	National Sanitation Foundation
NTU	Nephelometric Turbidity Units
OU	operable unit
oz	ounce
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
psi	pounds per square inch
PVC	polyvinyl chloride
PARCC	precision, accuracy, representativeness, completeness, and comparability
%C	percent completeness
%R	percent recovery
%RPD	Relative Percent Difference
QA	quality assurance
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QC	quality control
RA	Risk Assessment
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SOUTHNAVFACENGCOM	Southern Division, Naval Facilities Engineering Command
SOP	standard operating procedure
SOW	statement of work
SVOCs	semivolatile organic compounds
TAL	target analyte list
TCL	target compound list
TCLP	Toxicity Characteristic Leaching Procedure
TNT	trinitrotoluene
TPH	total petroleum hydrocarbons
USCS	Unified Classification System
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UZH	upper zone Hawthorn
UZS	upper zone surficial

## GLOSSARY (Continued)

VOAs	volatile organic aromatics
VOCs	volatile organic compounds

## 1.0 INTRODUCTION

1.1 GENERAL. This Sampling and Analysis Plan (SAP) describes the data collection and sample analytical procedures to be used in the Remedial Investigation and Feasibility Study (RI/FS) at the Naval Air Station (NAS) Cecil Field near Jacksonville, Florida (Figure 1-1). The RI/FS is being performed for Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) as part of the naval Installation Restoration (IR) program. The objective of the RI/FS is to identify and evaluate past hazardous waste sites and control the migration of hazardous contaminants from such sites. The Navy is proceeding with the IR program at NAS Cecil Field using the guidance of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Superfund Amendments and Reauthorization Act (SARA) RI/FS process. Based on the U.S. Environmental Protection Agency's (USEPA's) evaluation of data collected during previous investigations, the facility has been listed on the National Priority List (NPL).

This document covers the sampling and analytical activities at four operable units (OUs) containing a total of six sites. The approach to conducting the comprehensive RI/FS program at these sites is set forth in several planning documents. In addition to this SAP, these documents include the Workplan and the Health and Safety Plan (HASP). A comprehensive understanding of the entire program requires knowledge of all plans. This SAP details procedures for field sampling and data quality assurance (QA) and quality control (QC).

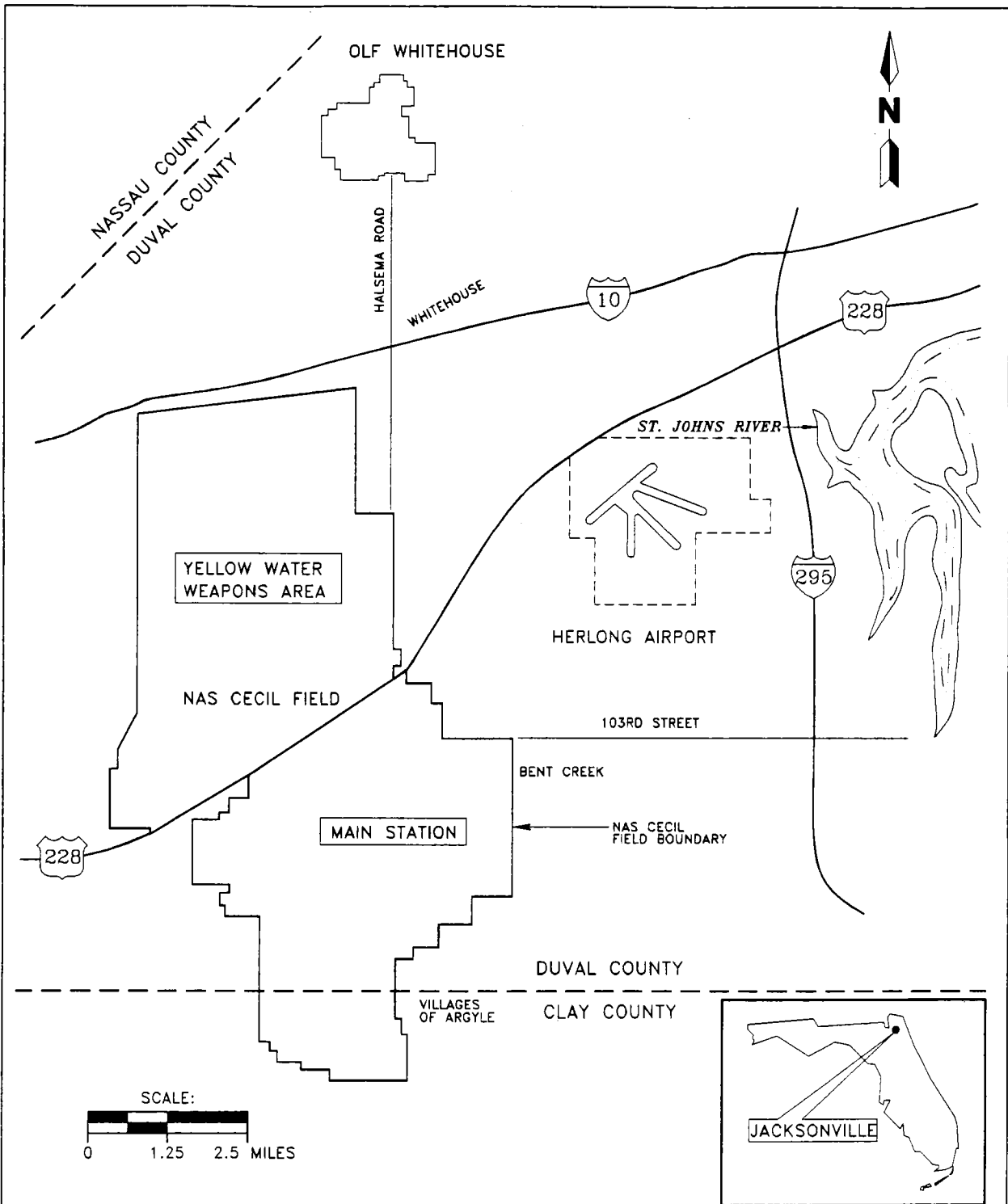
1.2 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY (RI/FS) GOALS. The goals of the RI/FS program are to assess the extent, magnitude, and impact of possible contamination at sites and to develop appropriate remedial actions for sites that are determined to pose a threat to human health and/or the environment. The RI/FS emphasizes the collection of sufficient information to support risk management decisions concerning the appropriate remediation at a given site.

The RI process serves as the mechanism for data collection to identify source and migration pathway characteristics and for conducting the risk assessment (RA) and testing necessary to aid in the FS process. The FS process uses the information collected in the RI to develop, screen, and evaluate potential remedial alternatives. The processes are conducted concurrently with data collection to provide information relevant to the selection of a remedial action.

1.3 RI/FS SITES. Locations of the six sites at NAS Cecil Field addressed in this program are shown on Figure 1-2. These sites have been grouped into four OUs based on suspected waste types and disposal practices. They consist of:

- firefighter training areas (OU 3 Sites 7 and 8),
- rubble pile area (OU 4 Site 10),
- ordnance sites (OU 5 Sites 14 and 15), and
- pesticide disposal area (OU 6 Site 11).

Site summaries for each site detailing suspected waste types, historical land use, and previous data collection results are included in Chapter 2.0 of the workplan.

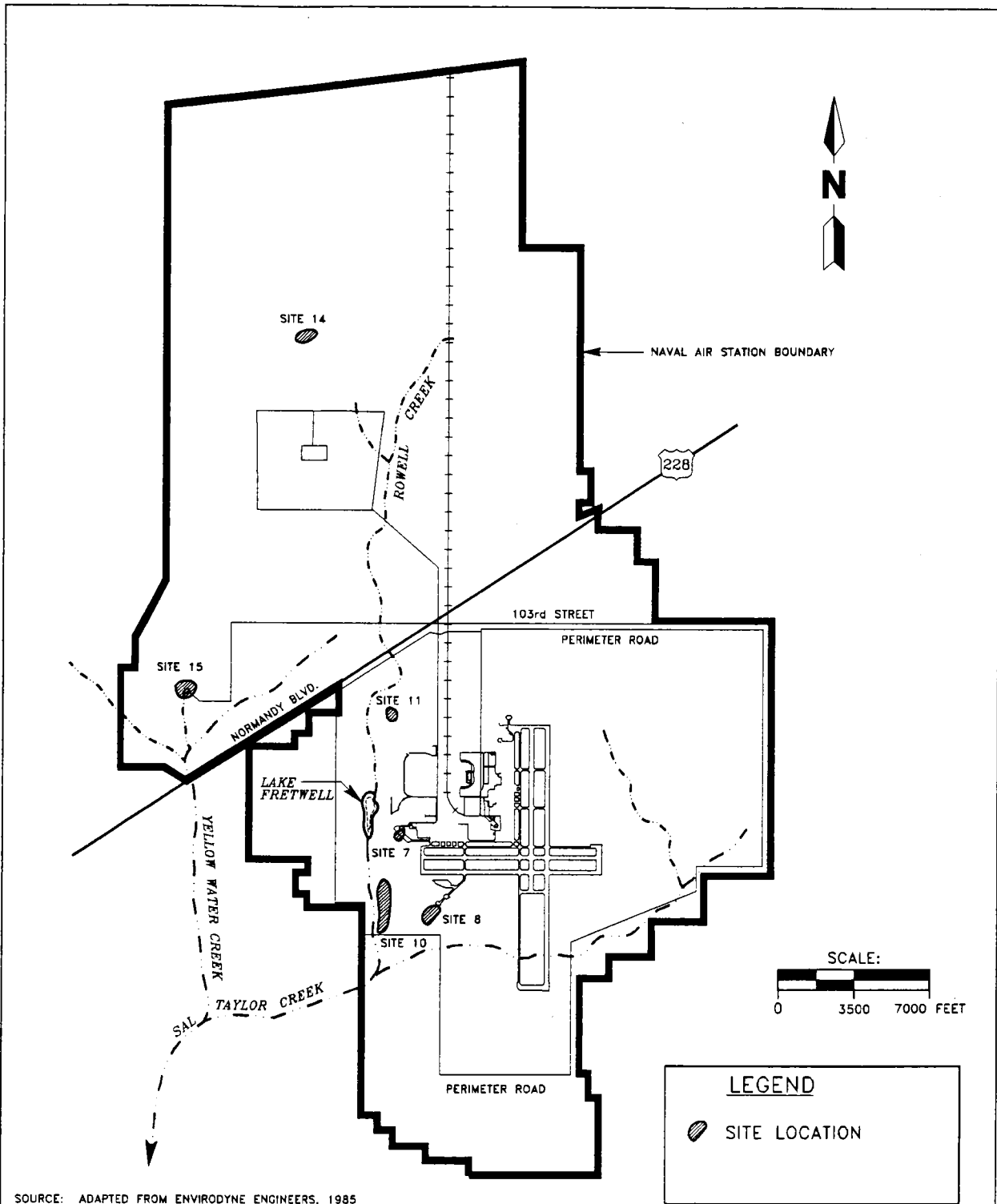


SOURCE: ADAPTED FROM ENVIRODYNE ENGINEERS, 1985

**FIGURE 1-1  
FACILITY LOCATION MAP**



**REMEDIAL INVESTIGATION/  
FEASIBILITY STUDY  
SAMPLING AND ANALYSIS PLAN  
OPERABLE UNITS 3,4,5, AND 6  
NAS CECIL FIELD  
JACKSONVILLE, FLORIDA**



SOURCE: ADAPTED FROM ENVIRODYNE ENGINEERS, 1985

**FIGURE 1-2**  
**SITE LOCATION MAP**

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**REMEDIAL INVESTIGATION/  
FEASIBILITY STUDY  
SAMPLING AND ANALYSIS  
OPERABLE UNITS 3,4,5, AND 6**

**NAS CECIL FIELD  
JACKSONVILLE, FLORIDA**

**1.4 CONTAMINATION STATUS AT EACH SITE.** A summary of the analytical data from previous investigations is included in Table 1-1. Primary contaminants of concern by site include:

- Site 7, metals (cadmium, chromium, and lead) and volatile organics (benzene and methylene chloride);
- Site 8, metals (lead) and volatile organics (1,1,1-trichloroethane and methylene chloride);
- Site 10, metals (chromium, lead, and mercury), extractable organics (bis(2-ethylhexyl)phthalate), and volatile organics (trichloroethene and trans-1,3-dichloropropene);
- Site 14, volatile organics (1,1,1-trichloroethane);
- Site 15, metals (lead) and extractable organics (polynuclear aromatic hydrocarbons); and
- Site 11, metals (chromium, lead, and arsenic), volatile organics (1,1,1-trichloroethane, toluene, and methylene chloride), and pesticides and herbicides (1,2-dibromo-3-chloropropane, parathion, alpha-benzene hexachloride (BHC), gamma-BHC, 2,4-dichlorophenoxyacetic acid, and toxaphene).

Samples from some monitoring wells revealed concentrations of chromium, lead, and benzene that were above Florida drinking water standards (Table 1-1). More detailed discussions of the previously identified contaminants and their migration potentials are provided in Chapters 2.0 and 3.0 of the Workplan. The HASP addresses field safety procedures and discusses health hazards associated with suspected contaminants.

**1.5 SCOPE OF THE SAMPLING AND ANALYTICAL PLAN.** The purpose of this SAP is to document the procedures for field activities and sample analyses. This plan was prepared in accordance with the USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988a). This plan discusses objectives of the sampling program and ultimate use of the data. It specifies sampling protocol and procedures as well as types, locations, frequency of samples to be collected; sample designations; sample handling and analyses; sampling equipment; and handling of investigative derived waste (IDW).

Chapter 2.0 consists of the Field Sampling Plan (FSP) and provides guidance for all fieldwork by defining, in detail, the sampling and data-gathering methods to be used on the project. Chapter 3.0 consists of the Quality Assurance Project Plan (QAPP) that describes the QA/QC protocols necessary to achieve the data quality objectives (DQOs) dictated by the intended use of the data.

**Table 1-1**  
**Summary of Maximum Measured Concentrations**

Remedial Investigation and Feasibility Study Sampling and Analytical Plan  
Operable Units 3, 4, 5, and 6  
NAS Cecil Field, Jacksonville, Florida

Site	Contaminant	Concentration
Site 7, Old Firefighter Training Area	Benzene (groundwater)	6 µg/ℓ <sup>1</sup>
	Cadmium (groundwater)	6 µg/ℓ <sup>1</sup>
	Chromium (groundwater)	61 µg/ℓ <sup>1</sup>
	Lead (groundwater)	50 µg/ℓ <sup>1</sup>
	Methylene chloride (soil)	53 µg/kg
	Cadmium (soil)	17 mg/kg
	Lead (soil)	14 mg/kg
Site 8, Firefighter Training Area, Boresite Test Range, and Hazardous Waste Storage Area	Chromium (groundwater)	28 µg/ℓ
	Lead (groundwater)	20 µg/ℓ <sup>1</sup>
	Methylene chloride (soil)	80 µg/kg
	1,1,1-Trichloroethane (soil)	82 µg/kg
	Chromium (soil)	16 mg/kg
	Lead (soil)	47 mg/kg
	Chromium (sediment)	6.2 mg/kg
	Lead (sediment)	4.7 mg/kg
Site 10, Rubble Disposal Area	1,1,1-Trichloroethane (sediment)	16 µg/kg
	bis (2-Ethylhexyl) phthalate (groundwater)	46 µg/ℓ
	Chromium (groundwater)	145 µg/ℓ <sup>1</sup>
	Lead (groundwater)	60 µg/ℓ <sup>1</sup>
	Mercury (groundwater)	0.8 µg/ℓ <sup>1</sup>
	Trichloroethene (groundwater)	1.6 µg/ℓ
	Trans-1,3-Dichloropropene (groundwater)	0.1 µg/ℓ
Site 11, Golf Course Pesticide Disposal Area	Chromium (groundwater)	332 µg/ℓ <sup>1</sup>
	Lead (groundwater)	573 µg/ℓ <sup>1</sup>
	1,2-dibromo-3-chloropropane (soil)	160 µg/kg
	Parathion (soil)	330 µg/kg
	Toluene (soil)	16 µg/kg
	Methylene chloride (soil)	24 µg/kg
	(25 µg/ℓ in QA/QC samples)	
	1,1,1-Trichloroethane (soil)	39 µg/kg
	(11 µg/ℓ in QA/QC samples)	
	Lead (soil)	8.3 mg/kg
	Aluminum (soil)	1690 mg/kg
	Arsenic (soil)	46.6 mg/kg
	Barium (soil)	3.4 mg/kg
	Chromium (soil)	4.6 mg/kg
	Copper (soil)	1.2 mg/kg
	Iron (soil)	623 mg/kg
	Magnesium (soil)	5.0 mg/kg
	Zinc (soil)	6.0 mg/kg
	alpha-BHC (product)	85 µg/kg
	gamma-BHC (product)	60 µg/kg
	2,4-Dichlorophenoxyacetic acid (product)	47,000 µg/kg
	1,2-dibromo-3-chloropropane (product)	
	toxaphene (product)	340,000 µg/ℓ
		73 µg/ℓ
See notes at end of table.		

**Table 1-1 (Continued)**  
**Summary of Maximum Measured Concentrations**

Remedial Investigation and Feasibility Study Sampling and Analytical Plan  
Operable Units 3, 4, 5, and 6  
NAS Cecil Field, Jacksonville, Florida

Site	Contaminant	Concentration
Site 14, Blue 5 Ordnance Disposal Area	1,1,1-Trichloroethane (soil)	11 µg/kg
Site 15, Blue 10 Ordnance Disposal Area	(Soil sampling)	
	Acenaphthene	6,600 µg/kg
	Anthracene	25,800 µg/kg
	Benzo(a)anthracene	176,400 µg/kg
	Benzo(a)pyrene	192,000 µg/kg
	Benzo(b)fluoranthene	352,800 µg/kg
	Benzo(g,h,i)perylene	103,800 µg/kg
	Benzo(k)fluoranthene	176,400 µg/kg
	Chrysene	202,500 µg/kg
	Fluoranthene	238,800 µg/kg
	Fluorene	3,000 µg/kg
	Indeno (1,2,3-cd) pyrene	108,900 µg/kg
	Naphthalene	5,700 µg/kg
	Phenanthrene	108,900 µg/kg
	Pyrene	275,100 µg/kg
	Lead	599 mg/kg

<sup>1</sup> Exceeds groundwater standards for Chapter 62-550, Florida Administrative Code, maximum contaminant levels.

Notes:     µg/l = microgram per liter.  
              µg/kg = microgram per kilogram.  
              mg/kg = milligram per kilogram.  
              QA/QC = quality assurance and quality control.  
              BHC = benzene hexachloride.

## 2.0 FIELD SAMPLING PLAN

**2.1 REMEDIAL INVESTIGATION APPROACH.** To collect the additional data required to complete the RI/FS for OUs 3, 4, 5, and 6 in a cost-effective manner, a two-stage comprehensive data collection approach was developed. An initial sampling event will be performed to preliminarily define the nature and extent of contamination at each site. A confirmatory sampling event will be performed to verify and supplement the results of the initial sampling event, if necessary. Note that the elements of the confirmatory sampling event are not discussed in this document (see Chapter 4.0 of the workplan for a discussion of this event). The actual confirmatory sampling event activities to be performed will be decided after the results of the initial sampling event activities have been received and jointly evaluated by the USEPA, Florida Department of Environmental Protection (FDEP), and Navy. Technical memoranda will then be prepared for the confirmatory sampling event activities.

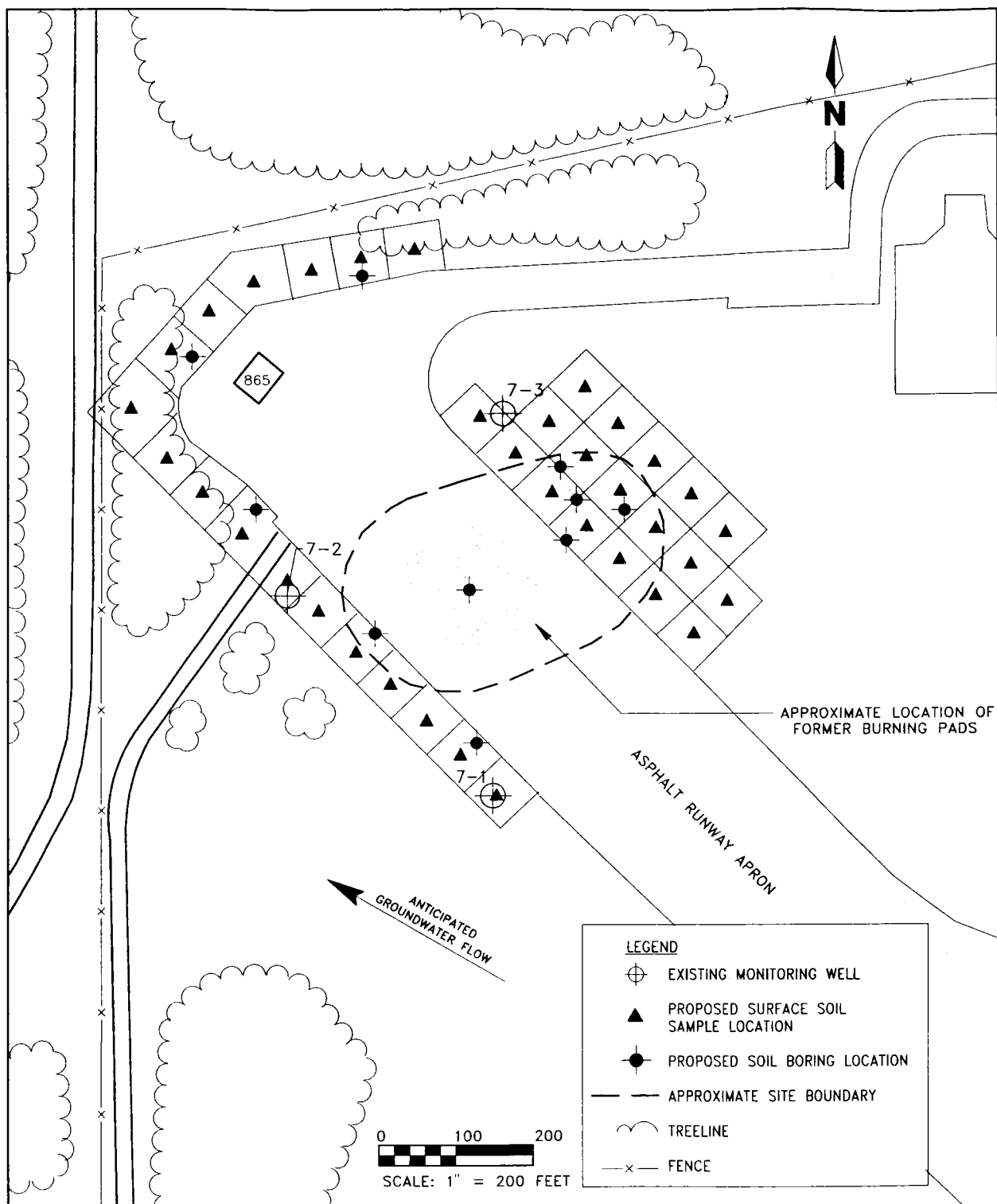
**2.2 DATA COLLECTION.** This section provides a brief description of the data collection program to be implemented during the initial sampling event activities at OUs 3, 4, 5, and 6. Chapter 4.0 of the workplan discusses the program in detail.

Sample codes were not assigned to the sampling locations on the figures because the dynamic nature of the screening program often changes many of the sample locations. However, all screening and confirmatory locations will be assigned codes at the time of collection and these codes will be used throughout the remainder of the RI.

**2.2.1 Background Characterization** Background soil samples will be collected from the Aquic Quartzipsamments, Sapelo fine sand, Olustee fine sand, and Leon fine sand soil units. Three background surface soil samples will be collected and three soil borings will be completed in each of the units. Soil samples will be collected from the soil borings at the surface and just above the water table. The locations of these background soil samples will be determined in the field, but generally will be from areas that appear to be unaffected by base operations or other development. All the background soil samples (estimated 36 total) will be sent to an offsite laboratory for full target compound list (TCL) and target analyte list (TAL) parameter analyses.

Three background monitoring wells (each with a 10-foot interval screened in the upper zone of the Hawthorn [UZH] formation) will be installed at the facility. One groundwater sample will then be collected from each of the existing and new background monitoring wells (12 total samples) and sent to an offsite laboratory for full TCL and TAL parameter analyses.

**2.2.2 Site 7, Old Firefighter Training Area** Both surface and subsurface soil samples will be collected for analysis at this site. One grab surface soil screening sample will be collected from the center of each 50-foot square grid block as shown on Figure 2-1 (35 total samples). These samples will be sent to the onsite laboratory for analyses of polynuclear aromatic hydrocarbons (PAHs) and total petroleum hydrocarbon (TPH) (USEPA Methods 8270 and 418.1), and to an offsite laboratory for analyses of lead (USEPA Method 6010). After the onsite laboratory analyses are completed, 20 percent of these sample locations (seven



**FIGURE 2-1**  
**PROPOSED SITE 7**  
**SOIL SAMPLING LOCATIONS**



**REMEDIAL INVESTIGATION/  
 FEASIBILITY STUDY  
 SAMPLING AND ANALYSIS PLAN  
 OPERABLE UNITS 3,4,5, AND 6**

**NAS CECIL FIELD  
 JACKSONVILLE, FLORIDA**

CECIL\RISTE7\GLC-NP\11-23-94

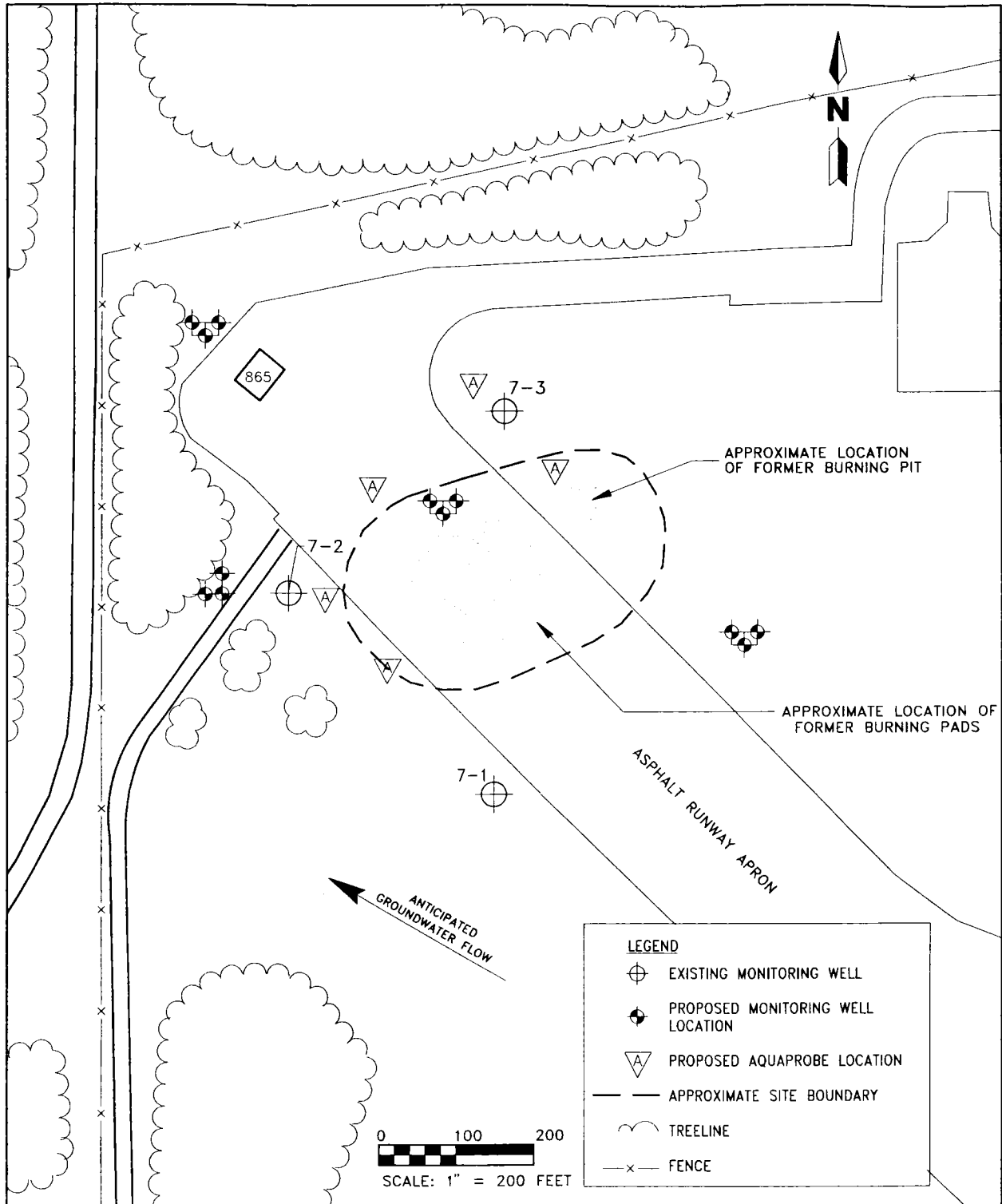
total samples) will be resampled, and these samples will be analyzed by an offsite laboratory for TCL and TAL parameters. The locations selected for resampling will be based on the onsite laboratory results with the intent being to collect these additional samples from the most contaminated areas.

Ten soil borings will be completed in and around the former burning pit and burning pad areas (after completion of surface soil sampling) at the approximate locations shown on Figure 2-1. Because the exact locations of the burning pit and burning pad areas are not visually evident at this site, the results of the surface soil sampling will be used to help guide exact placement of the soil borings. Soil screening samples will be collected at 2-foot intervals from the ground surface down to the water table (i.e., 0 to 1, 1 to 3, 3 to 5, and 5 to 7 feet below land surface [bls]). These samples (estimated 40 total) will be sent to the onsite laboratory and analyzed for volatile organic compounds (VOCs), PAHs, and TPH (USEPA Methods 8010 [modified], 8020 [modified], 8270, and 418.1), and to an offsite laboratory for analyses of lead (USEPA Method 6010). In addition, one sample per boring (10 total samples) will be sent to an offsite laboratory for full TCL and TAL parameter analyses, with the intent being to collect these samples from the most contaminated depths based on visual observation and field screening using a flame ionization detector (FID).

Groundwater screening samples will be collected using the Aquaprobe™ system in conjunction with hollow stem auger drilling technique. Groundwater samples will be collected from various depth intervals in the upper zone of the surficial (UZS) aquifer and the lower zone of the surficial (LZS) aquifer at each Aquaprobe™ location. These samples will be sent to the onsite laboratory and analyzed for VOCs and naphthalene (USEPA Modified Methods 8010 and 8020) and TPH (USEPA Method 418.1). Five pre-selected Aquaprobe™ sampling locations are shown on Figure 2-2. Other locations will be added in the field based on the onsite laboratory results for the first five and subsequent Aquaprobe™ sample locations, with the intent being to preliminarily define the areal extent of groundwater contamination.

Four, three-well monitoring well clusters will be installed at the site (after completion of the Aquaprobe™ sampling) at the approximate locations shown on Figure 2-2. The results of the groundwater and soil screening will be used to help guide areal and vertical placement of the monitoring well clusters with the intent being to locate one cluster in the source area, one cluster upgradient of the source area, and two clusters downgradient of the source area. Unless the stratigraphy dictates otherwise, one well in each cluster will be screened at the water table in the UZS, one well will be screened at the bottom of the LZS, and one well will be screened at the top of the UZH. After well installation is completed, one groundwater sample will be collected from each well (12 total samples) and sent to an offsite laboratory for full TCL and TAL analyses. If during purging, the turbidity readings of the groundwater are greater than 5 nephelometric turbidity units (NTUs), both a filtered and unfiltered sample will be sent to the offsite laboratory for TAL analyses. If turbidity readings are below 5 NTUs in all wells, only samples from the source area cluster of wells and one downgradient cluster of wells will be submitted for filtered and unfiltered TAL analyses.

During the construction of the UZH well in each of the new monitoring well clusters, the boring will be continuously logged (by visual observation of core samples) to the bottom of the UZH to characterize the lithology at the site.



**FIGURE 2-2**  
**PROPOSED SITE 7**  
**GROUNDWATER SAMPLING LOCATIONS**

CECIL\RISTE7\GLC-NP\11-23-94



**REMEDIAL INVESTIGATION/  
 FEASIBILITY STUDY  
 SAMPLING AND ANALYSIS PLAN  
 OPERABLE UNITS 3,4,5, AND 6**

**NAS CECIL FIELD  
 JACKSONVILLE, FLORIDA**

For the purposes of providing geotechnical, geochemical, and groundwater quality information to be used for potential remedial action, soil and groundwater samples will be collected as follows.

- One groundwater sample will be collected from the UZS and analyzed for:
  - pH, conductivity, and temperature (field measurement);
  - alkalinity (USEPA Method 310.1);
  - chloride (USEPA Method 325.1);
  - sulfate (USEPA Method 375.4);
  - total sulfide (USEPA Method 376.1);
  - oil and grease (USEPA Method 413.2);
  - total organic carbon (USEPA Method 415.2);
  - total solids (USEPA Method 160.3);
  - total suspended solids (USEPA Method 160.2);
  - total dissolved solids (USEPA Method 160.1);
  - hardness (USEPA Method 130.2); and
  - color (USEPA Method 110.2).
- One soil sample will be collected from the vadose zone in an area where no contamination appears to be present and analyzed for:
  - pH,
  - moisture content (American Society for Testing and Materials [ASTM] Method D-2216),
  - sieve and hydrometer particle size distribution (ASTM Methods D-421 and 422), and
  - bulk density (ASTM E12-70).
- For the evaluation of a potential remedial action involving excavation and disposal, one composite soil sample will be collected from the area in the vadose zone with the highest observed contamination and analyzed for:
  - Toxicity Characteristic Leaching Procedure (TCLP) extraction (VOCs, semivolatile organic compounds [SVOCs], metals, and pesticides as appropriate).
- For the evaluation of a potential remedial action involving biological treatment, one soil sample will be collected from the area in the vadose zone with the highest observed contamination and analyzed for:
  - total Kjeldahl nitrogen (USEPA Method 351.3),
  - ammonia-nitrogen (USEPA Method 350.2),
  - nitrate plus nitrite (USEPA Method 353.2),
  - total phosphorous (USEPA Method 365.1),
  - total bacteria (USEPA Method 907B modified),
  - specific petroleum degraders (USEPA Method 907B modified),
  - total organic carbon (USEPA method 415.2),
  - TPH (USEPA Method 418.1 modified), and
  - fingerprint (USEPA Method 3550/8100 modified).

Each new monitoring well will be surveyed horizontally and vertically to determine its precise location and elevation. One round of water level measurements will then be collected from the monitoring wells. In addition, *in-situ* hydraulic conductivity tests (slug tests) will be conducted in each new monitoring well.

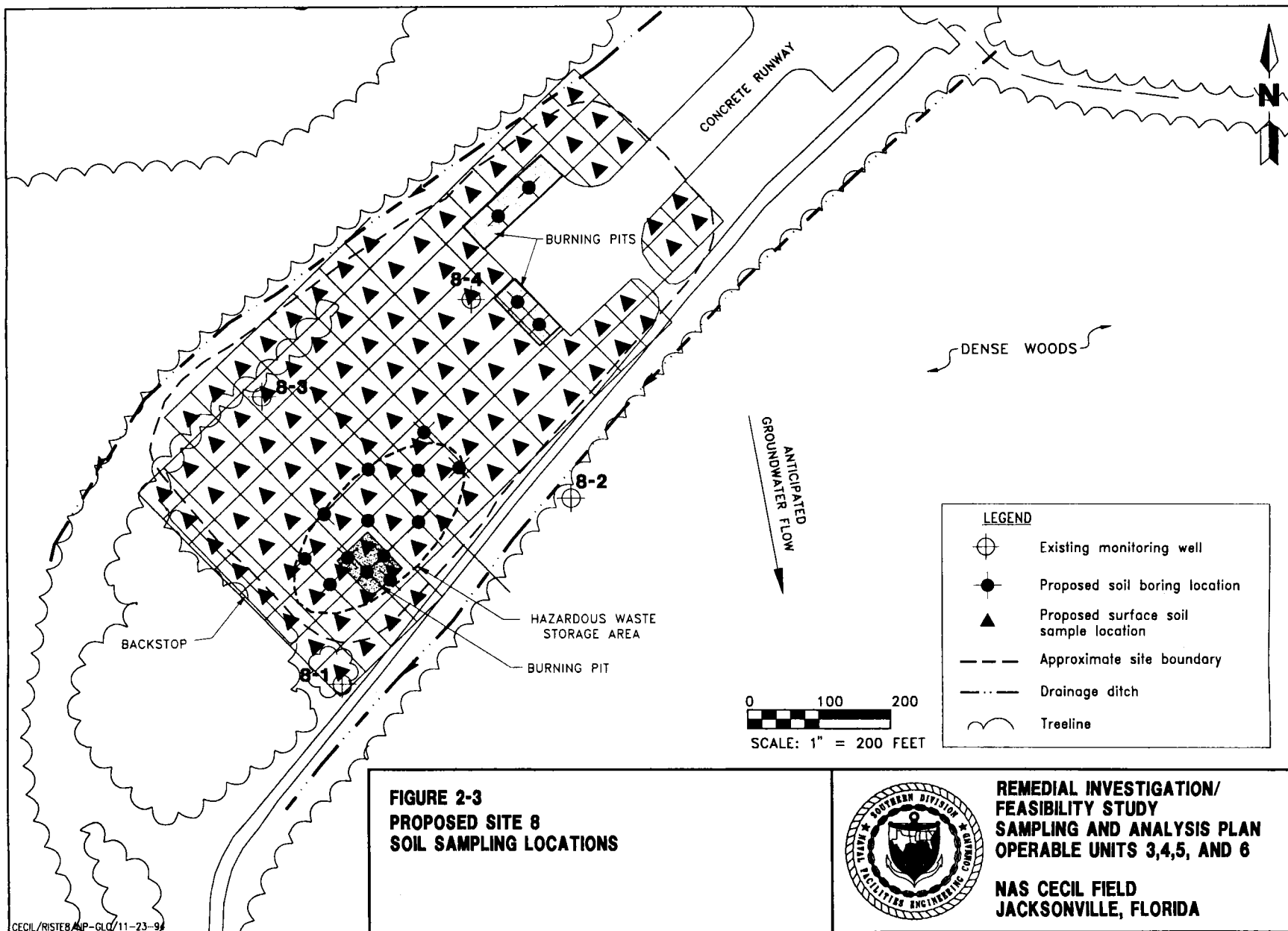
An ecological survey will be conducted on and around the site. An inventory of the biological community in the area will be conducted to identify the vegetative communities, habitat types, physical and chemical characteristics of the environment, the occurrence of animals, and any obvious zones of chemical contamination that could result in ecological effects.

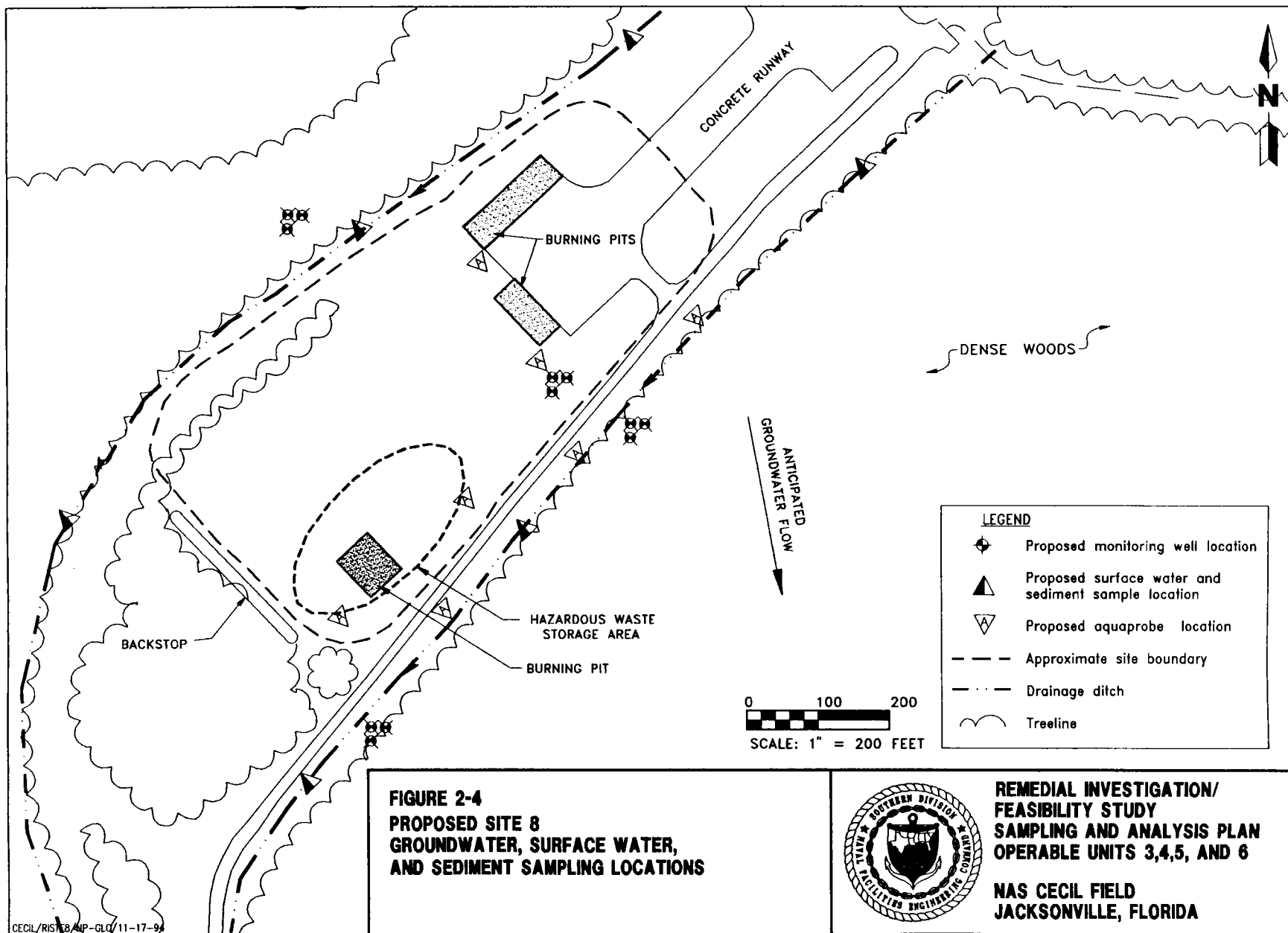
**2.2.3 Site 8, Firefighter Training Area, Boresite Test Range, and Hazardous Waste Storage Area** An ordnance survey will first be conducted at this site to identify the presence of and remove any unexploded ordnance. In addition, an ordnance survey will be conducted during all subsequent intrusive activities conducted on the site (i.e., soil borings and groundwater monitoring well installation).

Both surface and subsurface soil samples will be collected for analyses at this site. One grab surface soil screening sample will be collected from the center of each 50-foot square grid block as shown on Figure 2-3 (111 total samples). These samples will be sent to the onsite laboratory for analyses of PAHs and TPH (USEPA Methods 8270 and 418.1) and to an offsite laboratory for analyses of lead (USEPA Method 6010). After the onsite laboratory analyses are completed, 20 percent of these sample locations (22 total samples) will be resampled, and these samples will be analyzed by an offsite laboratory for full TCL and TAL parameters. The locations selected for resampling will be based on the onsite laboratory results with the intent being to collect these additional samples from the most contaminated areas due to firefighter training activities and from areas where hazardous wastes may have been spilled to verify the appropriateness of the screening parameters. All surface soil samples will be collected from 0 to 1 foot bls.

Six soil borings will be completed in the three burning pit areas and 10 soil borings will be completed in the hazardous waste storage area at the approximate locations shown on Figure 2-3. Soil screening samples will be collected at 2-foot intervals from the ground surface down to the water table. These samples (estimated 64 total, 16 surface and 48 subsurface samples) will be sent to the onsite laboratory and analyzed for VOCs, PAHs, and TPH (USEPA Methods 8010 (modified), 8020 (modified), 8270, and 418.1), and to an offsite laboratory for analyses of lead (USEPA Method 6010). In addition, one sample per boring (16 total samples) will be sent to an offsite laboratory for full TCL and TAL parameter analyses, with the intent being to collect these samples from the most contaminated depths based on visual observation and field screening using an FID.

Groundwater screening samples will be collected using the Aquaprobe™ system in conjunction with hollow stem auger drilling techniques. Groundwater samples will be collected from various depth intervals in the UZS and the LZS at each Aquaprobe™ location. These samples will be sent to the onsite laboratory and analyzed for VOCs and naphthalene (USEPA Modified Methods 8010 and 8020) and TPH (USEPA Method 418.1). Seven pre-selected Aquaprobe™ sampling locations are shown on Figure 2-4. Other locations will be added in the field based on the onsite laboratory results for the first seven and subsequent Aquaprobe™ sample locations,





with the intent being to preliminarily define the areal extent of groundwater contamination.

Four, three-well monitoring well clusters will be installed at the site (after completion of the Aquaprobe™ sampling) at the approximate locations shown on Figure 2-4. The results of the groundwater and soil screening will be used to help guide areal and vertical placement of the monitoring well clusters with the intent being to locate one cluster in the source area, one cluster upgradient of the source area, and two clusters downgradient of the source area. Unless stratigraphy dictates otherwise, one well in each cluster will be screened at the water table in the UZS, one well will be screened at the bottom of the LZS, and one well will be screened at the top of the UZH. After well installation is completed, one groundwater sample will be collected from each well (12 total samples) and sent to an offsite laboratory for full TCL and TAL analyses. Turbidity readings will be collected throughout purging and wells with values greater than 5 NTUs after purging will have both a filtered and unfiltered sample collected and sent to the offsite laboratory for TAL analyses. If turbidity readings are below 5 NTUs in all wells, only samples from the source area and one downgradient well clusters will be submitted for filtered and unfiltered TAL analyses.

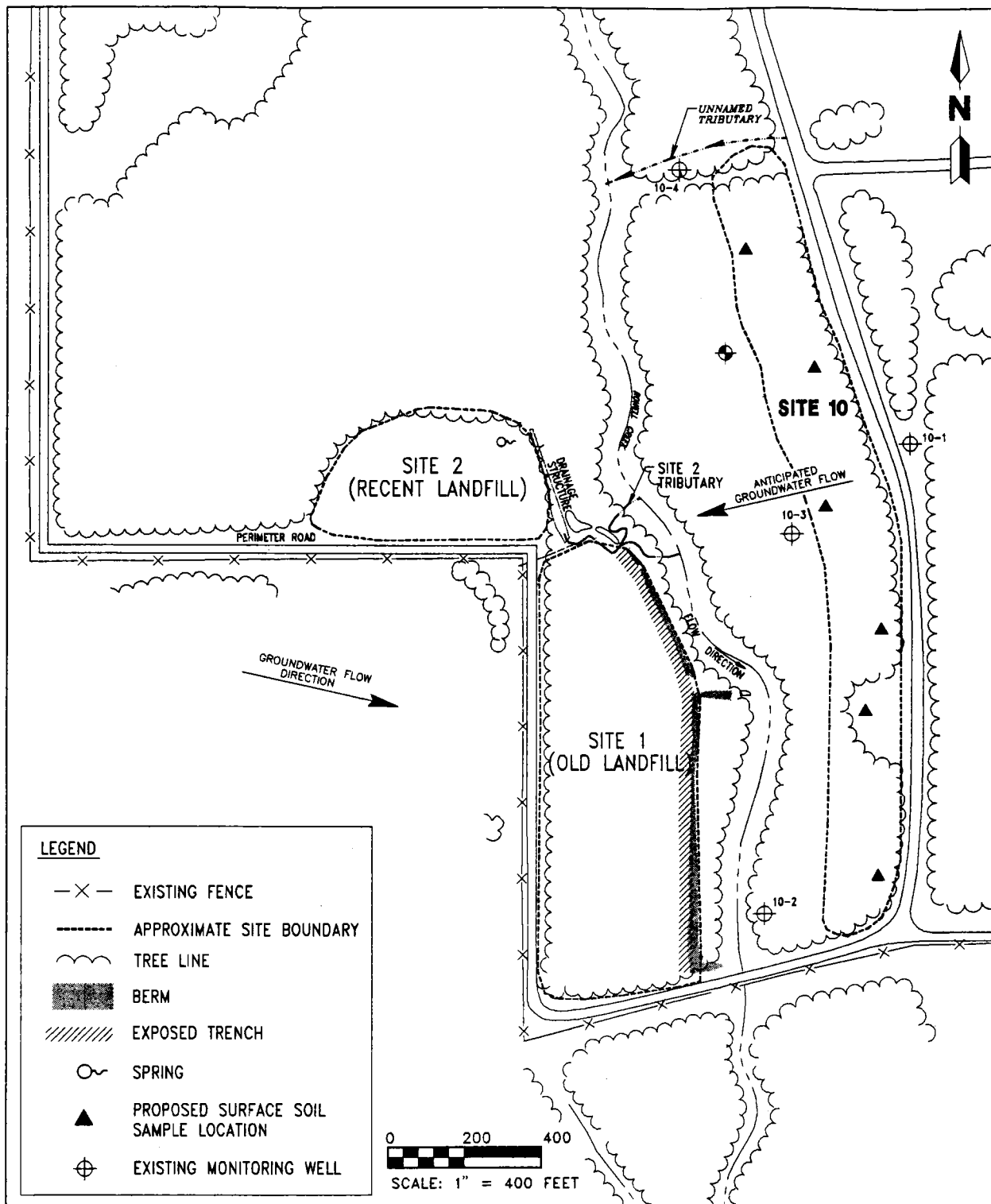
During the construction of the UZH well in each of the new monitoring well clusters, the boring will be continuously logged (by visual observation of core samples) to the bottom of the UZH to characterize the lithology at the site. Soil and groundwater samples will be collected and tested for the same suite of geotechnical and geochemical parameters as discussed in Subsection 2.2.2.

Each new monitoring well will be surveyed horizontally and vertically to determine their precise location and elevation. One round of water level measurements will then be collected from the monitoring wells. In addition, slug tests will be conducted in each new monitoring well.

Three surface water samples and three sediment samples will be collected from each of the two drainage ditches bordering the site as shown on Figure 2-4. These samples (six total surface water and six total sediment samples) will be sent to an offsite laboratory for full TCL and TAL parameter analyses. Both a filtered and unfiltered surface water sample will be sent to the offsite laboratory for TAL analyses.

An ecological survey will be conducted on and around the site. An inventory of the biological community in the area will be conducted to identify the vegetative communities, habitat types, physical and chemical characteristics of the environment, the occurrence of animals, and any obvious zones of chemical contamination that could result in ecological effects.

**2.2.4 Site 10, Rubble Disposal Area** For the purpose of identifying soil sample and monitoring well locations, the rubble piles will be mapped by visual observation and by staking the perimeter of each pile, followed by a survey to determine the location and elevation of each pile. Six surface soil samples will be collected at Site 10. The surface soil samples will be collected on the downgradient side of the six largest rubble piles. The samples will be collected from 0 to 1 foot bls. Approximate locations of surface soil samples are shown on Figure 2-5.



**FIGURE 2-5**  
**PROPOSED SITE 10**  
**SOIL SAMPLING LOCATIONS**



**REMEDIAL INVESTIGATION/  
 FEASIBILITY STUDY  
 SAMPLING AND ANALYSIS PLAN  
 OPERABLE UNITS 3,4,5, AND 6**

**NAS CECIL FIELD  
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One water table monitoring well will be installed (after the rubble piles have been mapped) on the downgradient side of the largest rubble pile at the approximate location shown on Figure 2-6. After well installation is completed, one groundwater sample will be collected from each new and existing well (five total) and sent to an offsite laboratory for full TCL and TAL analyses. Because the existing monitoring wells have not been sampled since 1988, they will be redeveloped prior to purging and sampling. If after purging, the turbidity readings of the water are greater than 5 NTUs, both a filtered and unfiltered sample will be sent to the offsite laboratory for TAL analyses; otherwise, only samples from the upgradient monitoring well and two downgradient monitoring wells will be submitted for filtered and unfiltered TAL analyses.

Each new and existing monitoring well will also be surveyed horizontally and vertically to determine their precise location and elevation. One round of water level measurements will then be collected from the monitoring wells to determine the directions of groundwater flow in each aquifer zone at the site. In addition, *in-situ* hydraulic conductivity tests (slug tests) will be conducted in each new monitoring well to provide estimates of the hydraulic properties of each aquifer zone at the site.

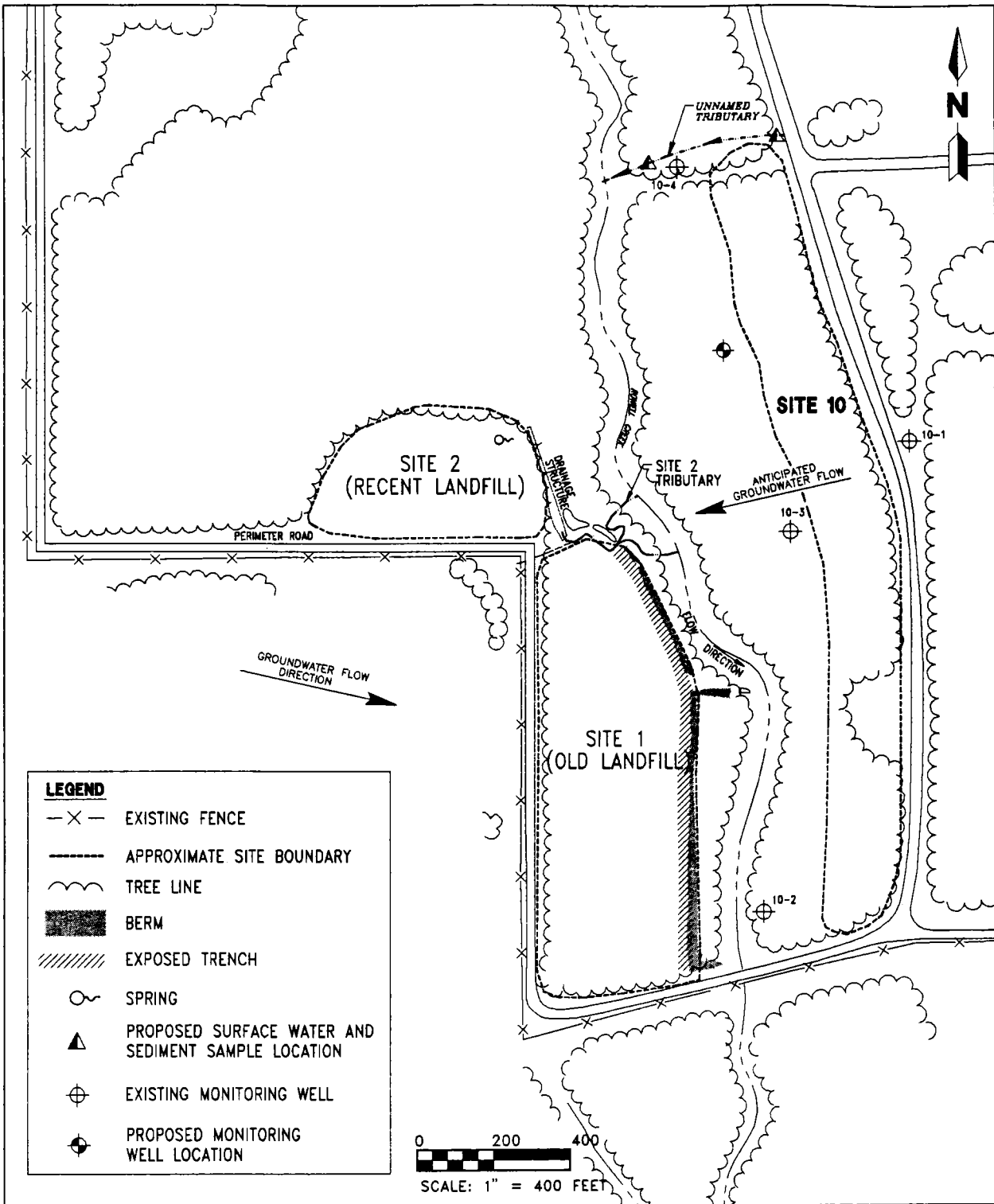
Two surface water samples and two sediment samples will be collected from the Rowell Creek tributary located north of the site as shown on Figure 2-6. These samples will be sent to an offsite laboratory for full TCL and TAL parameter analyses. Both a filtered and unfiltered surface water sample will be sent to the offsite laboratory for TAL analyses.

An ecological survey will be conducted on and around the site. An inventory of the biological community in the area will be conducted to identify the vegetative communities, habitat types, physical and chemical characteristics of the environment, the occurrence of animals, and any obvious zones of chemical contamination that could result in ecological effects.

**2.2.5 Site 14, Blue 5 Ordnance Disposal Area** An ordnance survey will first be conducted at this site to identify the presence of and remove any unexploded ordnance.

One grab surface sample will be collected from the center of each 100-foot square grid block as shown on Figure 2-7 (75 total samples). These samples will be screened onsite with 2,4,6-trinitrotoluene (TNT) colorimetric field test kits. In addition, surface soil samples will be collected from the center of each 50-foot square grid block around the bunker (Figure 2-7) and screened for USEPA modified methods 8010 and 8020 (24 total samples). An estimated 20 percent of these sample locations (15 samples) will be resampled and analyzed by an offsite laboratory for full TCL and TAL parameters and nitroaromatics (USEPA Method 8330). All surface soil samples will be collected from 0 to 1 foot bls.

Five temporary piezometers will be installed (prior to monitoring well installation) to assess groundwater flow direction and aid in the placement of monitoring wells. The piezometer locations are shown on Figure 2-7. Three, three-well monitoring well clusters will be installed at the site at the approximate locations shown on Figure 2-8. Unless the stratigraphy dictates otherwise, one well in each cluster will be screened at the water table in the UZS, one well will be screened at the bottom of the LZS, and one well will be screened at the top of the UZH. After well installation is completed, one



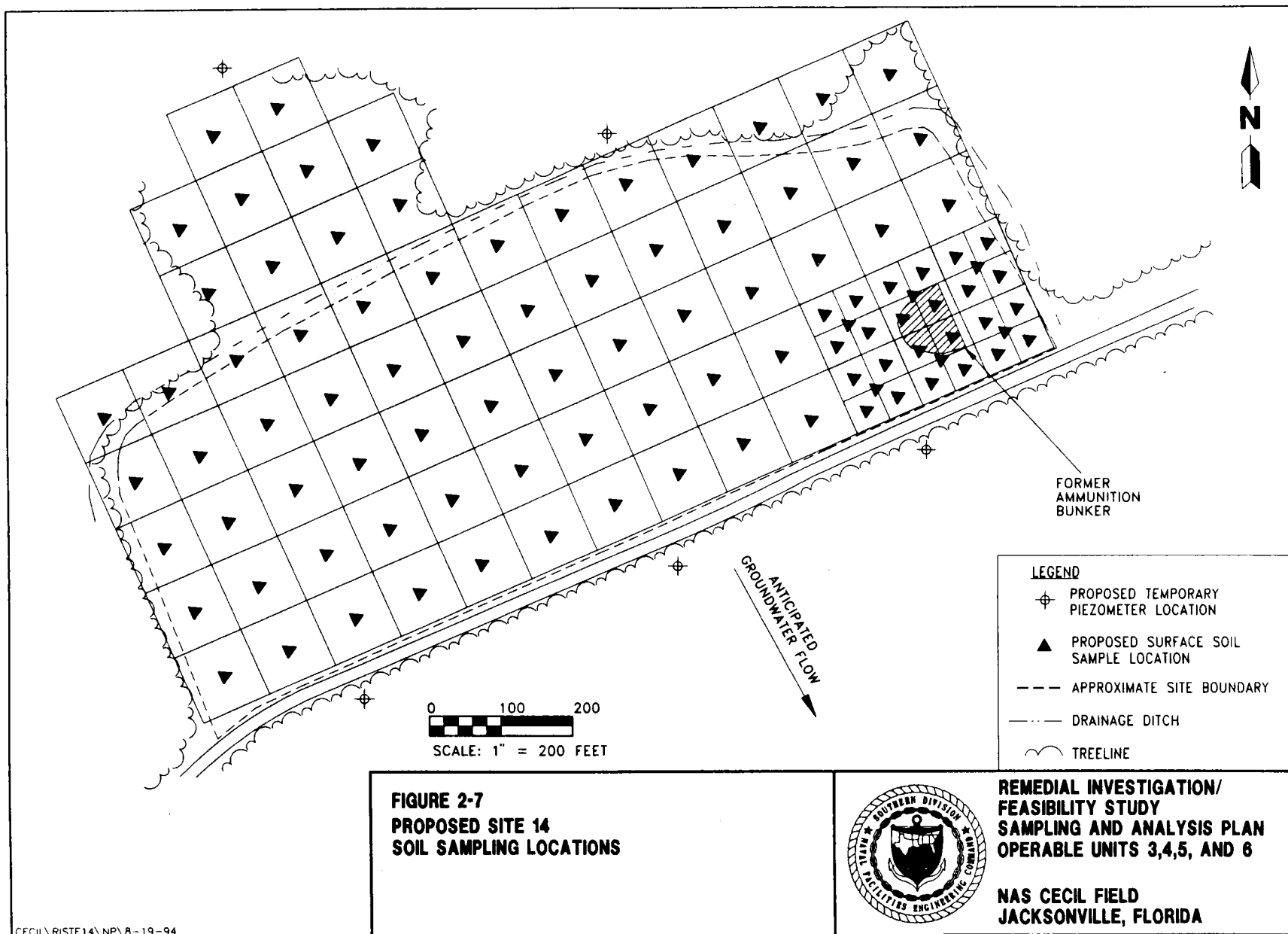
**FIGURE 2-6**  
**PROPOSED SITE 10**  
**GROUNDWATER, SURFACE WATER,**  
**AND SEDIMENT SAMPLING LOCATIONS**

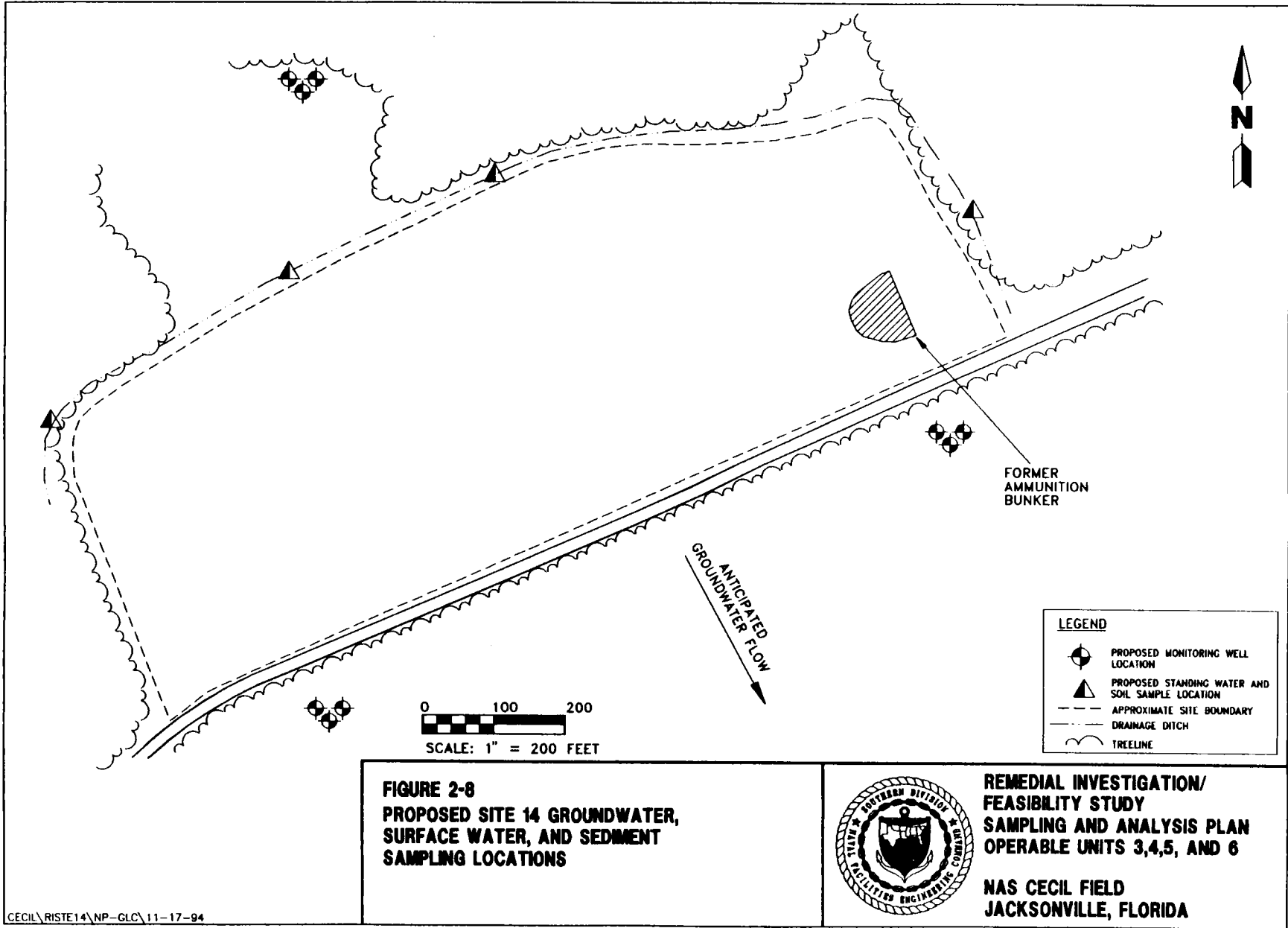


**REMEDIAL INVESTIGATION/  
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OPERABLE UNITS 3,4,5, AND 6**

**NAS CECIL FIELD  
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groundwater sample will be collected from each well and sent to an offsite laboratory for full TCL and TAL analyses, and nitroaromatic chemical analyses (USEPA Method 8330). If after purging, the turbidity readings of the water are greater than 5 NTUs, both a filtered and unfiltered sample will be sent to the offsite laboratory for TAL analyses. If turbidity readings are below 5 NTUs in all wells, only samples from the upgradient well cluster and one downgradient well cluster will be submitted for filtered and unfiltered TAL analyses.

During the construction of the UZH wells in each of the new monitoring well clusters, the boring will be continuously logged (by visual observation of core samples) to the bottom of the UZH to characterize the lithology at the site.

Each new monitoring well will be surveyed horizontally and vertically to determine their precise location and elevation. One round of water level measurements will then be collected from the monitoring wells. In addition, slug tests will be conducted in each new monitoring well.

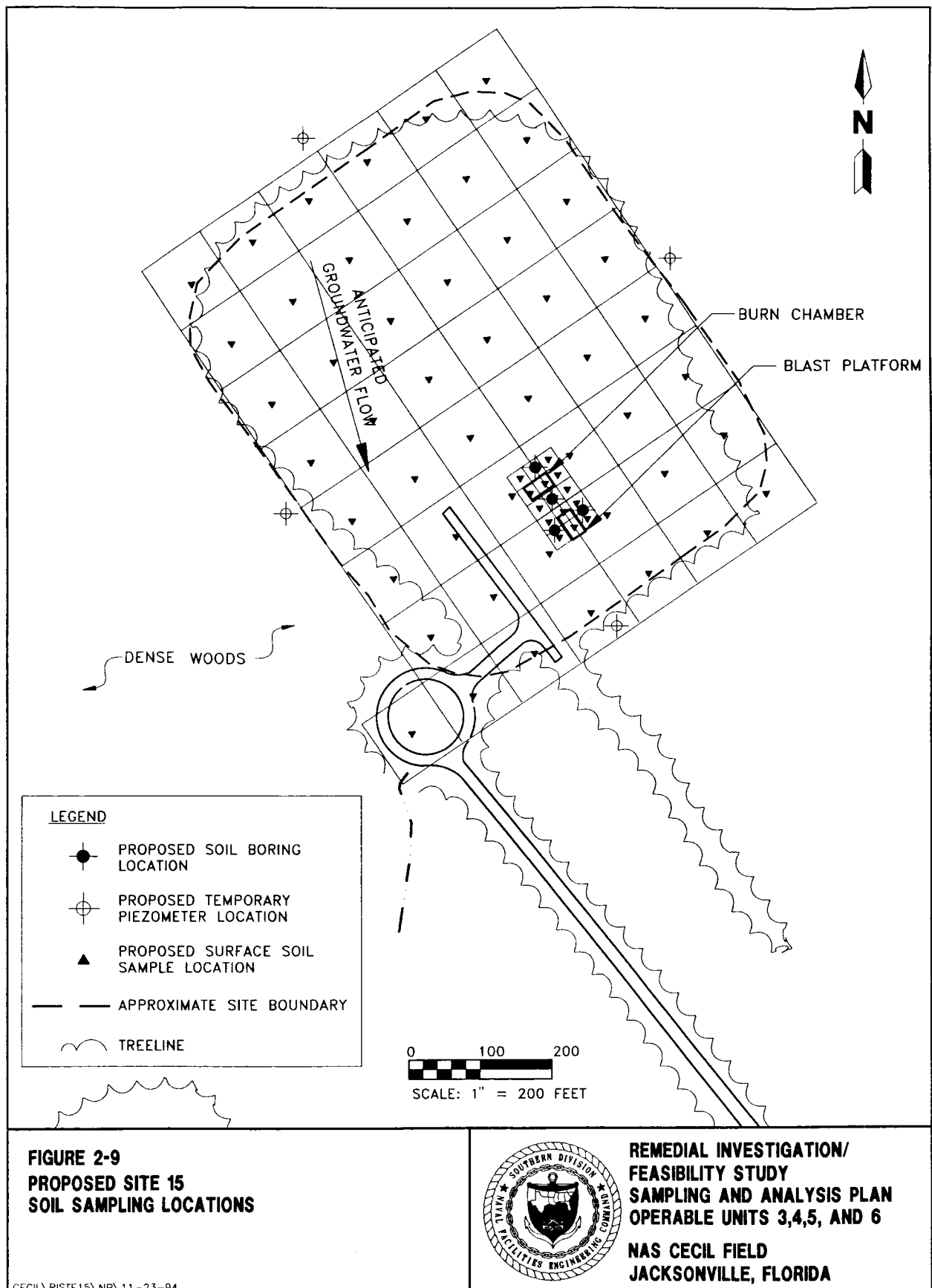
Four water samples and four soil samples will be collected from the drainage swale bordering the site as shown on Figure 2-8. These samples will be sent to an offsite laboratory for full TCL and TAL parameter analyses, and nitroaromatic chemical analyses (USEPA Method 8330). Both filtered and unfiltered water samples will be sent to the offsite laboratory for TAL analyses.

An ecological survey will be conducted on and around the site. An inventory of the biological community in the area will be conducted to identify the vegetative communities, habitat types, physical and chemical characteristics of the environment, the occurrence of animals, and any obvious zones of chemical contamination that could result in ecological effects.

**2.2.6 Site 15, Blue 10 Ordnance Disposal Area** An ordnance survey will first be conducted at this site to identify the presence of and remove any unexploded ordnance.

One grab surface soil screening sample will be collected from the center of each 25-foot and 100 foot square grid block as shown on Figure 2-9 (64 total samples). These samples will be sent to the onsite laboratory for analyses of PAHs and TPH (USEPA Methods 8270 and 418.1), and to an offsite laboratory for analyses of lead (USEPA Method 6010). The samples will also be screened with colorimetric field test kits for TNT. An estimated 20 percent of these sample locations (13 samples) will be resampled and analyzed by an offsite laboratory for full TCL and TAL parameters and nitroaromatics (USEPA Method 8330).

Four soil borings will be completed at locations with the highest contaminant concentration detected during the surface soil screening programs. Approximate soil boring locations are shown on Figure 2-9. Soil screening samples will be collected at 2-foot intervals from one foot bls down to the water table (i.e., 1 to 3, 3 to 5, and 5 to 7 feet bls). No samples will be collected from 0 to 1 foot bls because of the high density of proposed surface soil samples in this area of Site 15. These samples will be sent to an onsite laboratory and analyzed for VOCs, PAHs, and TPH (USEPA Methods 8010 [modified], 8020 [modified], 8270, and 418.1), and to an offsite laboratory for analyses of lead (USEPA Method 6010). In addition, one sample per boring (4 total samples) will be sent to an offsite laboratory for full TCL and TAL parameter analyses, with the intent being to



collect these samples from the most contaminated depths based on visual observation and field screening using an FID.

Four temporary piezometers will be installed (prior to monitoring well installation) to assess groundwater flow direction and subsequently aid in the placement of monitoring wells. The piezometer locations are shown on Figure 2-9.

Three, three well monitoring well clusters and a source area well will be installed at the site at the approximate location shown on Figure 2-10. Unless the stratigraphy dictates otherwise, one well in each cluster will be screened at the water table in the UZS, one well will be screened at the bottom of the LZS, and one well will be screened at the top of the UZH. After well installation is completed, one groundwater sample will be collected from each well and sent to an offsite laboratory for full TCL and TAL analyses and nitroaromatic chemical analyses (USEPA Method 8330). If after purging, the turbidity readings of the water are greater than 5 NTUs, both a filtered and unfiltered sample will be sent to the offsite laboratory for TAL analyses. If the turbidity readings are below 5 NTUs in all wells, only samples from the source area well cluster and one downgradient well cluster will be submitted for filtered and unfiltered TAL analyses.

During the construction of the UZH wells in each of the new monitoring well clusters, the boring will be continuously logged (by visual observation of core samples) to the bottom of the UZH to characterize the lithology at the site.

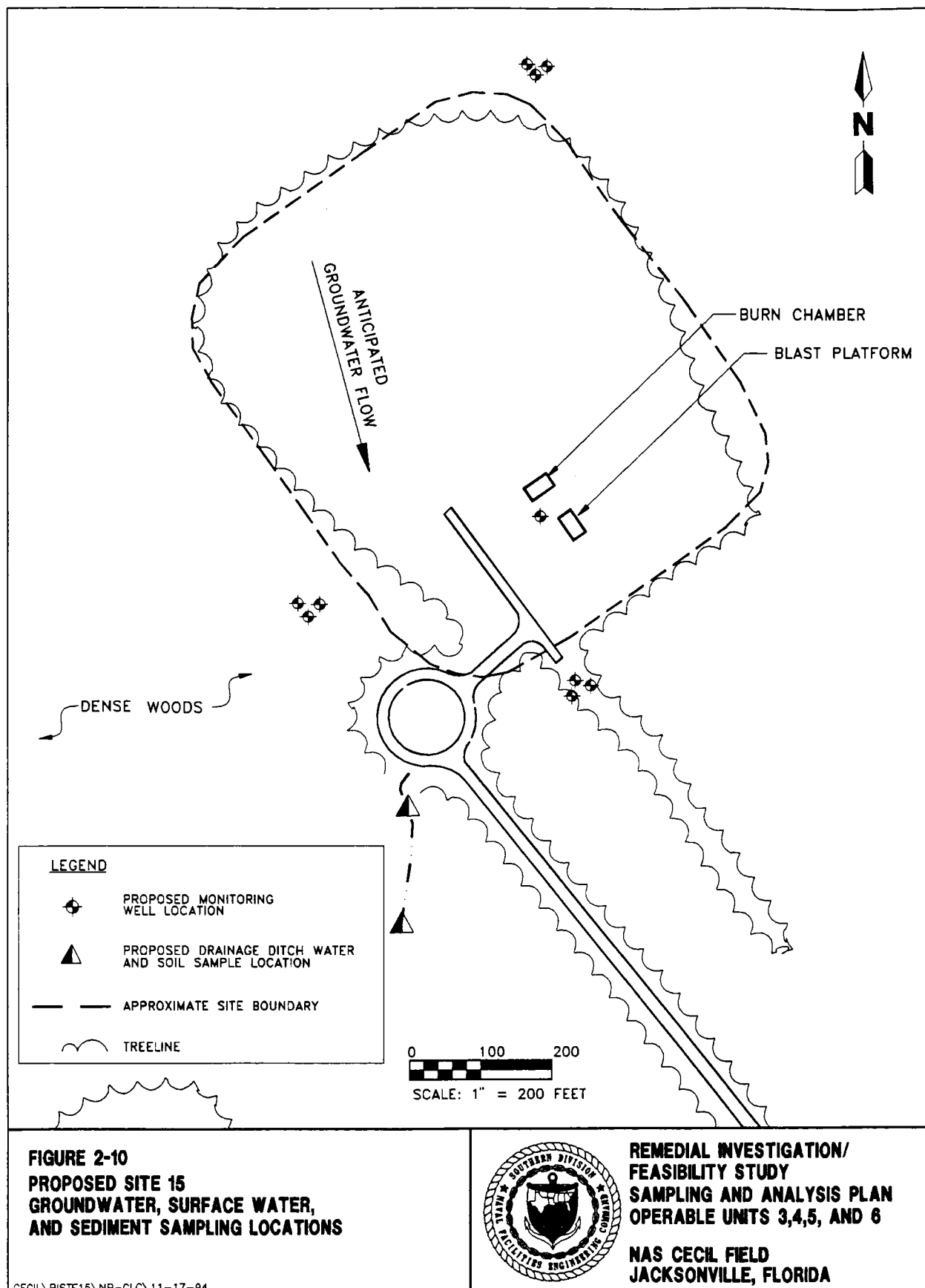
Soil and groundwater samples will be collected and tested for the same suite of geotechnical and geochemical parameters as discussed in Subsection 2.2.2.

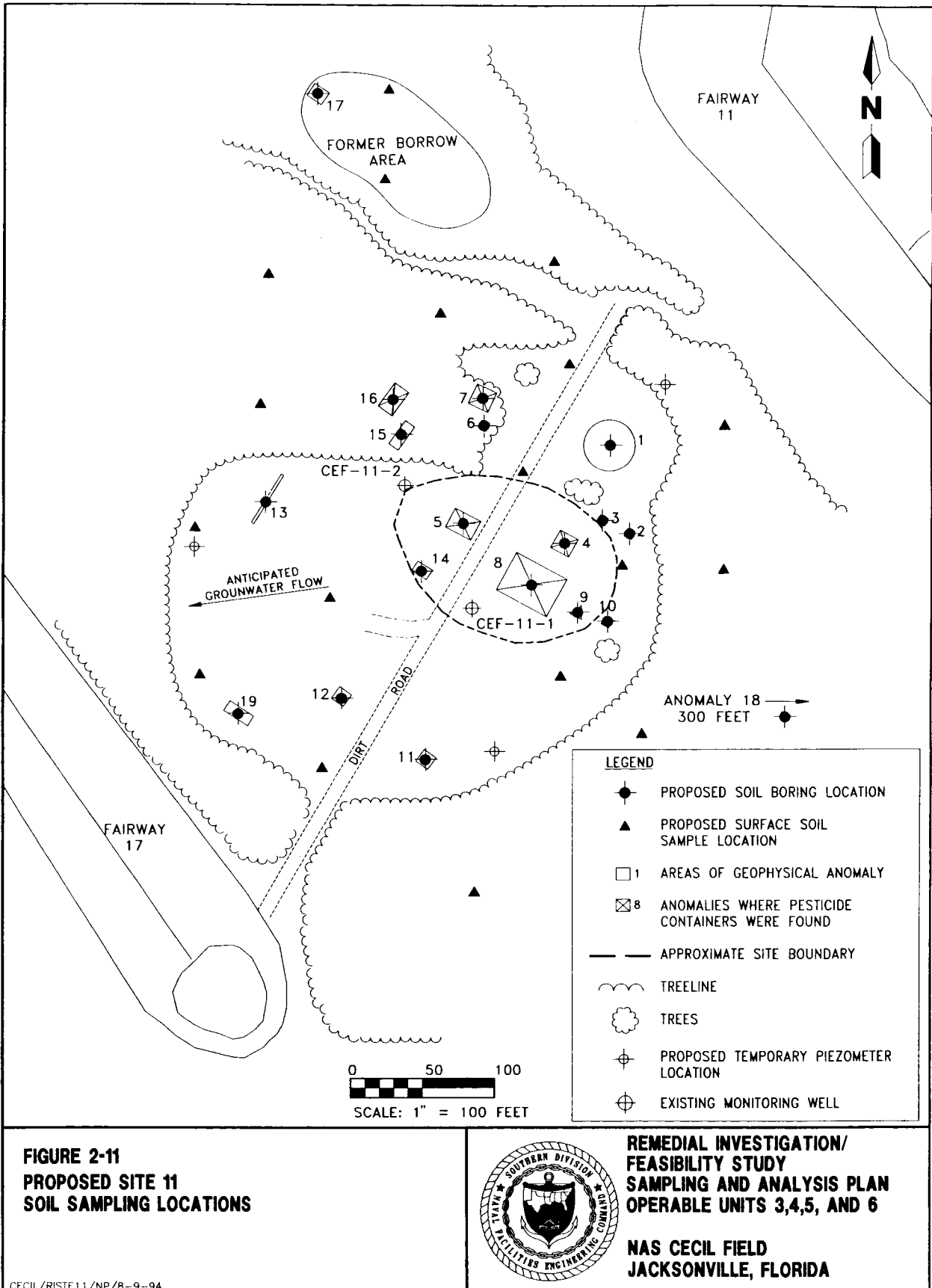
Each new monitoring well will be surveyed horizontally and vertically to determine their precise location and elevation. One round of water level measurements will then be collected from the monitoring wells. In addition, slug tests will be conducted in each new monitoring well.

Two surface water samples (if present) and two soil samples will be collected from the drainage ditch leaving the site as shown on Figure 2-10. These samples will be sent to an offsite laboratory for full TCL and TAL parameter analyses and nitroaromatic chemical analyses (USEPA Method 8330). Both a filtered and unfiltered surface water sample (if available) will be sent to the offsite laboratory for TAL analyses.

An ecological survey will be conducted on and around the site. An inventory of the biological community in the area will be conducted to identify the vegetative communities, habitat types, physical and chemical characteristics of the environment, the occurrence of animals, and any obvious zones of chemical contamination that could result in ecological effects.

**2.2.7 Site 11, Pesticide Disposal Area** Both surface and subsurface soil samples will be collected for analyses at this site. Nineteen soil borings will be completed at the approximate locations shown on Figure 2-11. One soil boring will be completed in each of the 19 anomalous areas identified in the 1993 geophysical survey of the site. One soil sample will be collected at the surface (0 to 1 foot bls) and one soil sample will be collected just above the water table in each of these boreholes. These samples (38 total samples) will be sent to an offsite laboratory for full TCL and TAL parameter analyses, and for analyses of other





pesticides and herbicides potentially associated with this site (USEPA Methods 8150, 8140, and 1,2-dibromo-3-chloropropane).

Grab surface soil samples will be collected from the areas between the soil borings as shown on Figure 2-11. These samples (19 total samples) will be sent to an offsite laboratory for TCL and TAL parameter analyses and for analytical of other pesticides and herbicides potentially associated with this site (USEPA Methods 8150, 8140, and 1,2-dibromo-3-chloropropane).

Three temporary piezometers will be installed (prior to monitoring well installation) to assess groundwater flow direction and subsequently aid in the placement of monitoring wells. The piezometer locations are shown on Figure 2-11.

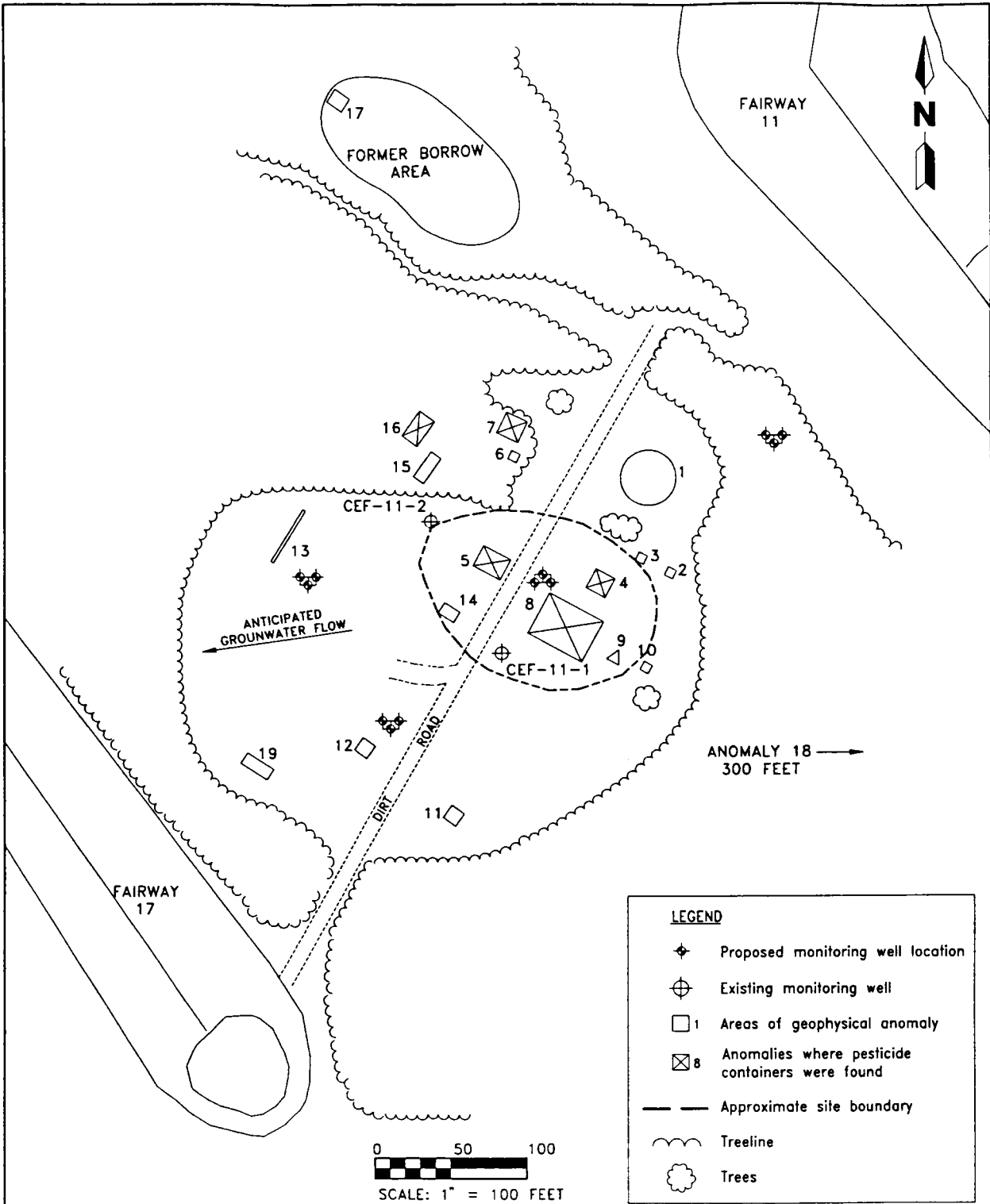
Four, three-well monitoring well clusters will be installed at the site at the approximate locations shown on Figure 2-12. Unless stratigraphy dictates otherwise, one well in each cluster will be screened at the water table in the UZS, one well will be screened at the bottom of the LZS, and one well will be screened at the top of the UZH. After well installation is completed, one groundwater sample will be collected from each well and sent to an offsite laboratory for full TCL and TAL analyses and for analyses of other pesticides and herbicides potentially associated with this site (USEPA Methods 8150, 8140, and 1,2-dibromo-3-chloropropane). If after purging, the turbidity readings of the water are greater than 5 NTUs, both a filtered and unfiltered sample will be sent to the offsite laboratory for TAL analyses. If turbidity readings are below 5 NTUs in all wells, only samples from the source area cluster and one downgradient well cluster will be submitted for filtered and unfiltered TAL analyses.

During the construction of the UZH well in each of the new monitoring well clusters, the boring will be continuously logged (by visual observation of core samples) to the bottom of the UZH to characterize the lithology at the site. Soil and groundwater samples will be collected and tested for the same suite of geotechnical and geochemical parameters as discussed in Subsection 2.2.2.

Each new monitoring well will be surveyed horizontally and vertically to determine their precise location and elevation. One round of water level measurements will then be collected from the monitoring wells. In addition, slug tests will be conducted in each new monitoring well.

An ecological survey will be conducted on and around the site. An inventory of the biological community in the area will be conducted to identify the vegetative communities, habitat types, physical and chemical characteristics of the environment, the occurrence of animals, and any obvious zones of chemical contamination that could result in ecological effects.

**2.3 DATA QUALITY OBJECTIVES** The intended use of data and the required DQOs are best defined during the planning stages to ensure that collection, decontamination, containerization, shipping, and analytical methods are consistent with the degree of confidence required of the resultant data. The DQOs for the RI are presented in Chapter 4.0 of the workplan. The purpose of the RI is to provide the data necessary for source, migration pathway, and potential receptor characterization in sufficient detail to support the evaluation of potential remedial alternatives through the FS process. The workplan approach to data



**FIGURE 2-12  
PROPOSED SITE 11  
GROUNDWATER SAMPLING LOCATIONS**



**REMEDIAL INVESTIGATION/  
FEASIBILITY STUDY  
SAMPLING AND ANALYSIS PLAN  
OPERABLE UNITS 3,4,5, AND 6**

**NAS CECIL FIELD  
JACKSONVILLE, FLORIDA**

CECIL/RISTE11/NP/8-10-94

collection is to ensure that site characterization efforts are directed towards providing information relevant to selection of remedial actions.

**2.3.1 Task-Specific Data Quality Objectives** The DQOs are to characterize the site, delineate the source of contamination, and determine whether contamination has migrated away from the source and, if so, by which pathways. Source characterization and delineation include: a geophysical survey and collection and analyses of samples of soil, surface water, sediment, and groundwater. Other data will be used to evaluate contaminant migration potential (permeability tests, surface water and groundwater level data, etc.). Tasks for the RI/FS at NAS Cecil Field will involve data collection with DQOs ranging from Level I through Level IV (defined in Chapter 4.0 of the workplan). The following discusses the primary RI/FS tasks for NAS Cecil Field and the associated DQO level.

**2.3.1.1 Headspace Screening, Level I** Split-spoon samples from discrete depths in soil borings will be screened in the field with an FID providing Level I data concerning the presence or absence of VOCs.

**2.3.1.2 Air Quality Monitoring, Level I** For health and safety purposes, air quality will be monitored in the breathing zone by an FID and by a dustmeter, providing Level I data concerning the presence or absence of VOCs and dust.

**2.3.1.3 Field Parameter Analyses, Level I** Field measurements of surface water and groundwater temperature, pH, specific conductance, and turbidity will be performed. These measurements are both quantitative and qualitative and the data generated conform with Level I DQOs.

**2.3.1.4 Aquifer Testing and Measurement, Level I** Slug tests will be conducted in each new monitoring well constructed in the surficial aquifer to estimate the horizontal hydraulic conductivity of the aquifer media. In addition, one round of groundwater level measurements will also be collected from each new monitoring well. These measurements are both quantitative and qualitative and the data generated conform with Level I DQOs.

**2.3.1.5 Surveying, Level I** The inner casing (riser) for all new monitoring wells will be surveyed for both horizontal and vertical control to a minimum degree of accuracy of 0.1 and 0.01 foot, respectively. The locations of all soil, surface water, and sediment samples collected, as well as other pertinent features identified during the investigation, will also be surveyed for horizontal and vertical control to a minimum degree of accuracy of 0.1 foot. The information collected will be Level I data.

**2.3.1.6 Characterization Sampling, Level III** Groundwater and soil samples will be collected and analyzed by an onsite laboratory in accordance with Level III DQOs during the initial screening activities at Sites 7, 8, 14, and 15.

**2.3.1.7 Characterization Sampling, Level IV** A percentage of the soil samples collected and all groundwater, surface water, and sediment samples collected during the RI field program will be collected and analyzed in conformance with Level IV DQOs and USEPA Contract Laboratory Program (CLP) methods.

These RI/FS data will be used, as applicable, for health and safety monitoring, site characterization, public health and ecological risk assessment, and evaluating remedial alternatives.

**2.4 SITE MANAGEMENT.** Site Management involves such tasks as mobilizing and demobilizing from the facility, obtaining access to the sites, documenting all activities during the investigation, acquiring instruments to be used during the field program, establishing decontamination procedures to be implemented for various equipment, and ensuring proper disposal of IDW. These tasks are described in detail below.

**2.4.1 Mobilization** The following activities will be performed at NAS Cecil Field as part of mobilization:

- command post setup, including office and sample management trailer, communications (i.e., two-way radios), utility hookups, and portable toilets;
- staking and utility clearance of all exploration locations;
- field team orientation, including acquisition of personnel badges and security clearances for work in secure areas; and
- a field team and subcontractor health and safety meeting.

**2.4.2 Site Access and Control** NAS Cecil Field is an active Navy base with controlled site access. Several areas on base are high security areas requiring controlled area badges. Where necessary, security police will be notified about on-base locations of ABB Environmental Services, Inc. (ABB-ES), personnel during field activities. A base escort may be required while conducting field explorations in the restricted areas. Badges will be obtained through the base security. All sites on base are accessible from paved or dirt roads maintained by the base.

**2.4.3 Documentation** Documentation and records of all procedures performed during the RI field investigation will be maintained as described below. All documentation will be placed in the NAS Cecil Field project files.

**2.4.3.1 Operations Logbook** A bound site logbook for each task will be used to record information concerning daily operations during the field program. Data entry into logs, forms, and notebooks will be written in ink and initialed by the author. Entry errors in the logbook or field notebooks will be crossed out with a single line and initialed. The Field Operations Leader (FOL) will be responsible for completing the site logbook.

**2.4.3.2 Field Logbooks** Field logbooks will document the details of each activity during the field investigation. Field team personnel will be responsible for data entry in field logbooks. These bound logbooks will document investigative and sampling activities for each site including equipment and assembling decontamination activities, sample collection, visual observations, sample handling, and shipping. These logbooks will be supported by field data sheets and logs. Entries will be as descriptive and detailed as possible, so that a particular situation could be reconstructed without reliance on the collector's memory.

All entries will be made with indelible ink and legibly written. The language will be factual and objective. No erasures will be permitted. If an incorrect entry is made, the data will be crossed out with a single strike mark, initialed, and dated. The following guidelines will be implemented for all logbooks:

- each page will be signed, dated, and numbered;
- blank pages will be marked as such;
- each entry will be identified with the time (24 hour clock); and
- logbook extensions (field sheets and logs) will be recorded.

**2.4.3.3 Field Data Sheets and Logs** Field data sheets and logs will be maintained by field team personnel who will document items (e.g., sample location and information, field measurements, soil identification, boring information, and equipment calibration). Examples of the field sheets and logs to be used during the RI are included in Appendix A.

**2.4.3.4 Calibration Logbook** Instruments will be calibrated and inspected daily before field activities begin, after daily activities, and as suggested by the manufacturers. Calibration information will be recorded in a calibration logbook.

**2.4.3.5 Field Change Forms** Deviations from the workplan and SAP during the field investigative program will be documented on field change forms. The FOL will be responsible for completing the forms.

**2.4.3.6 Plans** A copy of the RI/FS workplan, the HASP, and the SAP (including the FSP and QAPP) will be kept onsite. Copies of the HASP will be placed in the operations trailer and issued to each field team. Appropriate plans including standard operating procedures (SOPs) and the SAP will also be provided to each field team.

**2.4.4 Field Monitoring Instrumentation** The following monitoring instruments may be used during field activities at NAS Cecil Field for health and safety monitoring:

- FID,
- explosimeter,
- dustmeter (i.e., Miniram™),
- noise meter,
- radiation badges, and
- Dräger tubes (benzene, vinyl chloride, trichloroethene, and trichloroethane).

Instruments to be used for field measurements include:

- pH, temperature, and specific conductance meter;
- turbidity meter; and
- electronic water level meter.

Instruments will be calibrated and inspected daily before field activities begin, after daily activities, and as suggested by the manufacturers. Air monitoring safety equipment used in the field will be calibrated and inspected each time they are turned on, in accordance with the *Region IV Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual* (ECBSOPQAM) (USEPA, 1991). Any equipment not specifically referenced in this document will be calibrated and maintained according to the manufacturers' specifications. Calibration information will be recorded in a calibration logbook that will be kept on file at the field office trailer. Malfunctioning instruments will be repaired or replaced. Monitoring equipment will be protected from contamination during field exploration activities as much as possible without hindering

operation of the unit. Equipment maintenance will be performed according to manufacturer specifications before field use or by cycling units out of the field. As appropriate, routine periodic maintenance may be performed as a function of field calibration. SOPs, including calibration and maintenance procedures, for each piece of field equipment to be used during the RI are included in Appendix B.

**2.4.5 Equipment Decontamination Procedures** To assure that analytical results reflect the actual concentrations present at sampling locations, chemical sampling and field analytical equipment will be properly decontaminated offsite prior to the field effort, onsite during the sampling program (i.e., between sampling points), and onsite at the conclusion of the sampling program. This will minimize the potential for cross contamination between sample points and the transfer of contamination offsite. Field decontamination procedures conducted during a field event will be documented in the field logbook.

This section addresses the decontamination procedures for chemical sampling and field analytical equipment as well as for drilling equipment. These cleaning procedures are based on the ECBSOPQAM (USEPA, 1991). To clarify the decontamination procedures, the following definitions have been used.

Detergent will be a standard brand of phosphate-free laboratory detergent such as Alconox™ or Liquinox™.

Acid solution will be made from reagent-grade nitric acid and deionized water.

Tap or potable water will be treated water from any municipal water treatment system.

Deionized water will be tap water that has been treated by passing through a standard deionizing resin column.

Organic-free water will be tap water that has been treated with activated carbon and deionizing units. It will contain no pesticides, herbicides, extractable organic compounds, and less than 5 micrograms per liter ( $\mu\text{g}/\text{l}$ ) of purgeable organic compounds as measured by a low level gas chromatograph and mass spectrometer (GC/MS) scan. This organic-free water will be used for blank preparation and for final rinse in decontamination.

Solvent will be pesticide-grade isopropanol.

**2.4.5.1 Field Decontamination Procedures** It is ABB-ES policy to transport to the field (when practical) sufficient equipment so that the entire study can be conducted without the need for field cleaning. However, when this is not possible, the following field decontamination procedures from the ECBSOPQAM (USEPA, 1991) will be followed. A semi-permanent decontamination pad will be constructed for decontamination purposes at a location determined in coordination with the Navy.

Sampling Equipment for Organic and Metal Analyses. Teflon™, stainless-steel, glass, or metal sampling equipment used to collect samples for organic and metal analyses will be cleaned between sample locations as listed below.

1. Wash and scrub equipment thoroughly with laboratory detergent and tap water.

2. Rinse thoroughly with tap water.
3. Rinse thoroughly with deionized water.
4. Rinse twice with solvent (pesticide-grade isopropanol).
5. Rinse with organic-free water and allow to air dry as long as possible.
6. If organic-free water is not available, allow equipment to air dry as long as possible. Do not rinse again with deionized or distilled water.

Note that deionized water, organic-free water, and solvents must be dispensed from glass, Teflon™, or stainless-steel containers.

**2.4.5.2 Large Equipment Decontamination** Large equipment (e.g., drill rigs, augers, drill pipe, casing, and screen) will be cleaned prior to use and between sample locations in accordance with the ECBSOPQAM (USEPA, 1991) as outlined below.

**Cleaning Procedures Prior to Initiation of Field Work.** Any portion of the drill rig that will be over the borehole or sampling location (e.g., kelly bar or mast, drilling platform, hoist or chain pulldowns, cathead, etc.) will be decontaminated prior to arriving at the site as described below.

1. Steam clean and wire brush to remove soil and rust.
2. Inspect to assure that seals and gaskets are intact and that there are no residual oils, grease, or hydraulic fluids that could drip into the sample location.
3. If necessary, use Teflon™ string to tighten drill stem.
4. Steam clean the drill rig prior to drilling each borehole.

If the downhole equipment and tools have paint on them, they will have to be sandblasted to remove the paint to prevent cross contamination.

**Cleaning Procedures for Downhole Equipment.** Drilling, sampling, and associated equipment that will come in contact with the downhole sampling medium will be cleaned as outlined below.

1. Wash and scrub with tap water and laboratory-grade detergent.
2. Steam clean and/or high pressure wash, if necessary, to remove soil. The steam cleaner or high pressure washer should be capable of generating a pressure of at least 2,500 pounds per square inch (psi) and producing hot water and/or steam (200 °Fahrenheit [°F] and above).
3. Rinse thoroughly with tap water.
4. Rinse thoroughly with deionized water.
5. Rinse twice with solvent. Note: do not rinse polyvinyl chloride (PVC) materials with solvent.

6. Rinse thoroughly with organic-free water and allow to air dry.
7. If organic-free water is not available, allow equipment to air dry. Do not rinse again with deionized or distilled water.
8. Where appropriate, wrap with aluminum foil to prevent contamination during storage. Augers, drill stems, casings, and other large items can be wrapped in clean plastic if necessary.
9. If caked mud, rust, and/or paint is present that cannot be removed by steam or high pressure wash, the downhole equipment will be sandblasted prior to step number 1 above, and prior to arrival onsite.
10. Printing and/or writing on well casing, screens, tremie, tubing, etc., will be removed with emery cloth or sand paper prior to arrival onsite. Where possible, materials without printing or writing will be ordered.

Note that deionized water, organic-free water, and solvents must be dispensed from glass or Teflon™ containers.

**2.4.5.3 Well Development and Aquifer Testing Equipment** All equipment used for well development will be decontaminated before and after use at each well. This will include, but is not limited to, decontamination of all pumps, purging bailers, and downhole piping.

The decontamination procedures will be similar to those described for drilling equipment (steam clean, detergent wash, solvent rinse, and organic-free water rinse).

**2.4.5.4 Water Level Measurement Equipment** The electrical (sounding) tape or steel tape used to measure water levels will be cleaned before and after use at each well to avoid chemical cross contamination between wells. The procedure will include an organic-free water rinse for sites without detected decontamination and a full decontamination for sites where contamination is present. The tape will be placed in a polyethylene bag for storage or transportation.

**2.4.5.5 Decontamination Staging Area and Fluid Disposal** Cleaning and decontamination of all equipment will occur at a designated area onsite that is downgradient and downwind (prevailing wind direction) of the clean equipment drying and storage area. The cleaning and decontamination area will contain an excavated pit, lined with heavy duty plastic sheeting, for containment of washwater and waste. The pit will be designed such that washwater will drain into the pit. Solvent rinsates will be collected in separate containers. Large portable equipment (drill rods, auger flights, well casing and screen, etc.) will be cleaned on saw horses or other supports constructed above the plastic sheeting.

The water in the pit will be pumped into 55-gallon drums and the sediment will be collected in separate drums. The plastic sheeting will be washed and the wastewater will be containerized as contaminated washwater. The plastic sheeting will then be properly disposed. The pit will be backfilled with the originally excavated material.

The drums containing waste will be properly labeled, sealed, and staged for storage until laboratory analytical results are received. The contaminated material will be treated as discussed in Subsection 2.4.6.

**2.4.6 Control and Disposal of Investigation-Derived Waste (IDW)** Wastes will be generated as a byproduct of the RI field investigation. The *Investigation Derived Waste Management Plan* (ABB-ES, 1994) will be followed when dealing with the waste. Types of wastes to be generated include:

- drill and auger cuttings,
- wastewater from decontamination,
- well development and purge water, and
- disposable health and safety clothing and sampling tools.

**2.5 SAMPLE COLLECTION.** All sample collection during this investigation will be in accordance with the SOPs specified in Sections 3, 4, and 6 of the ECBSOPQAM (USEPA, 1991). The onsite laboratory analyses used during this investigation will follow USEPA methods as stated in *Test Methods for Evaluating Solid Waste, Third Edition, SW-846* (USEPA, 1986) and *Methods for Chemical Analytical of Water and Wastes* (USEPA, 1983). Table 5-1 of the workplan summarizes the total number of samples to be collected and includes all QC samples.

**2.6 SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES.** Table 2-1 presents a summary of samples to be collected according to the media and analytical parameters. For planning purposes and to document the required considerations associated with sample containers, preservation, and holding times, the sample media are placed in the following categories:

- aqueous environmental media including surface water, groundwater, and aqueous QA/QC samples, and
- solid environmental media including sediment and soil.

Table 2-1 provides a comprehensive listing of the considerations, according to the analyses to be performed, required for each of these categories. The table is based on the ECBSOPQAM (USEPA, 1991).

For the majority of sampling episodes, ABB-ES obtains sample containers from a Naval Energy and Environmental Support Activity (NEESA)-approved subcontract laboratory. ABB-ES and NEESA require all subcontract laboratories to have a current and comprehensive QA plan and sample container requirements that meet USEPA CLP QA requirements. The origin of sample containers is noted in equipment files. ABB-ES obtains sample containers from suppliers that meet USEPA CLP QA requirements; ABB-ES currently contracts with I-CHEM Research, Inc. Records of I-CHEM bottles and their certification paperwork for each bottle lot are maintained by the ABB-ES equipment manager.

In general, samples for organic analyses should be stored in glass containers and samples for inorganic analyses should be stored in plastic containers. When sample containers are stored onsite, the containers should be kept sealed and as far as possible from stored solvents. Ideally, solvents should be kept in separate facilities from clean containers and organic-free water. Preservatives

**Table 2-1**  
**Sample Containers, Preservatives, and Holding Times**

Remedial Investigation and Feasibility Study Sampling and Analytical Plan  
Operable Units 3, 4, 5, and 6  
NAS Cecil Field, Jacksonville, Florida

Analysis	Sample Matrix	Analytical Method <sup>1</sup>	Sample Preservation	Holding Time	Containers
VOA	Soil	Ref. 1 and USEPA Method 8010/8020 (Ref. 3)	Cool to 4 °C	14 days	1-16 oz glass wide-mouth, Teflon™-lined septa
Base Neutral Acid (BNA) and Pesticide and PCB	Soil	Ref. 1	Cool to 4 °C	14 days to extraction, 40 days to analytical	1-16 oz glass wide-mouth, Teflon™-lined lid
Metals and Cyanide	Soil	Ref. 2	Cool to 4 °C	6 months	1-16 oz glass wide-mouth, Teflon™-lined lid
PAHs	Soil	USEPA Method 8270 (Ref. 3)	Cool to 4 °C	14 days	1-16 oz glass wide-mouth, Teflon™-lined lid
TPH	Soil	USEPA Method 418.1 (Ref. 4)	Cool to 4 °C	28 days	1-16 oz glass wide-mouth, Teflon™-lined lid
Lead	Soil	USEPA Method 6010 (Ref. 3)	Cool to 4 °C	6 months	1-16 oz glass wide-mouth, Teflon™-lined lid
Nitroaromatic	Soil	USEPA Method 8330 (Ref. 3)	Cool to 4 °C	7 days to extraction, 40 days to analytical	1-16 oz glass wide-mouth, Teflon™-lined lid
Additional Pesticide/-Herbicide	Soil	USEPA Methods 8150/8140 and 1,2-dibromo-3-chloropropane (Ref. 3)	Cool to 4 °C	14 days to extraction, 40 days to analytical	1-16 oz glass wide-mouth, Teflon™-lined lid
VOA	Aqueous	Ref. 1	Cool to 4 °C <sup>2</sup>	14 days	2-40 mL glass vial, Teflon™-lined septa
BNA and Pesticide and PCB <sup>3</sup>	Aqueous	Ref. 1	Cool to 4 °C	7 days to extraction, 40 days to analytical	1-1 gallon glass amber, Teflon™-lined septa
Metals <sup>3</sup>	Aqueous	Ref. 2	Cool to 4 °C HNO <sub>3</sub> to pH < 2	6 months, Hg - 28 days	1-1 L poly, poly-lined closure
Cyanide <sup>3</sup>	Aqueous	Ref. 2	Cool to 4 °C <sup>4</sup> NaOH to pH > 12	14 days	1-1 L poly, poly-lined closure
VOA + Naphthalene <sup>5</sup>	Aqueous	USEPA Methods 8010/8020 (modified) (Ref. 3)	Cool to 4 °C <sup>2</sup>	14 days	2-40 mL glass vial, Teflon™-lined septa
See notes at end of table.					

**Table 2-1 (Continued)**  
**Sample Containers, Preservatives, and Holding Times**

Remedial Investigation and Feasibility Study Sampling and Analytical Plan  
Operable Units 3, 4, 5, and 6  
NAS Cecil Field, Jacksonville, Florida

Analysis	Sample Matrix	Analytical Method <sup>1</sup>	Sample Preservation	Holding Time	Containers
TPH	Aqueous	USEPA Method 418.1 (Ref. 4)	Cool to 4 °C	7 days to extraction, 40 days to analytical	1-1 ℓ glass amber, Teflon™-lined lid
Nitroaromatic	Aqueous	USEPA Method 8330 (Ref. 3)	Cool to 4 °C	7 days to extraction, 40 days to analytical	1-80 oz glass amber, Teflon™-lined lid
Additional Pesticide and Herbicide	Aqueous	USEPA Methods 8150/8140 and 1,2- dibromo-3-chloropropane (Ref. 3)	Cool to 4 °C	7 days to extraction, 40 days to analytical	1-80 oz glass amber, Teflon™-lined lid
<p><sup>1</sup> Reference 1 is "Statement of Work for Organic Analytical, Multi-Concentration" Document No. OLM01 with all revisions, U.S. Environmental Protection Agency (USEPA) Contract Laboratory Program (CLP), revised June 1991. Reference 2 is "Statement of Work for Inorganic Analytical, Multi-Concentration" Document No. ILM03 with all revisions, USEPA CLP, revised March 1990. Reference 3 is "Test Methods for Evaluating Solid Waste, Third Edition, SW-846" USEPA Office of Solid Waste and Emergency Response, Washington, DC, November 1986. Reference 4 is "Methods for Chemical Analytical of Water and Wastes" USEPA Office of Research and Development, Cincinnati, Ohio, March 1983, EPA 600/4-79-020.</p> <p><sup>2</sup> Adjust pH of aqueous VOA samples to &lt;2 by the drop-wise addition, to the two 40 mL VOA vials, of 1:1 HCl (made with demonstrated organic-free water) prior to filling with sample. Determine the number of acid drops required on a third sample aliquot (of equal volume)--do not acidify sample if effervescence is observed and indicate on sample that no acid preservative has been added.</p> <p><sup>3</sup> One field sample must be collected in double volume for matrix spike and matrix spike duplicate analyses.</p> <p><sup>4</sup> Check for residual chlorine before preservation. Chlorine: Test a drop of sample on KI starch paper. If blue, add ascorbic acid crystals until a drop of sample produces no color on indicator paper. Then add an additional 0.6 g ascorbic acid/L sample volume.</p> <p><sup>5</sup> Via modified USEPA Methods 8010 and 8020 to include the detection of naphthalene per the onsite laboratory standard operating procedures.</p> <p>Notes: VOA = volatile organic aromatic. USEPA = U.S. Environmental Protection Agency. °C = degrees Celsius. oz = ounce. BNA = base neutral acid. PCB = polychlorinated biphenyl. PAHs = polynuclear aromatic hydrocarbons.</p> <p>TPH = total petroleum hydrocarbon. mℓ = milliliters. HNO<sub>3</sub> = nitric acid. ℓ = liters. NaOH = sodium hydroxide. HCl = hydrochloric acid.</p>					

will be added in the field by ABB-ES personnel. Samples will be preserved immediately upon collection in the field.

**2.7 SAMPLE IDENTIFICATION.** Samples collected for laboratory analyses during the field investigation will be labeled with a sample identification code, which identifies the installation, site location, sample type, sample location and number, and modifier as described below. This coding system will provide a tracking procedure to allow retrieval of information concerning a particular sample and assure that each sample is uniquely identified.

The sample identification system consists of alphanumeric characters in five information groups:

- installation,
- site,
- type,
- sample location and number, and
- modifier.

These information groups may contain the following entries. If no information is required for the particular sample, the spaces will be filled with an X.

**Installation** The installation code identifies the facility:

CF = the NAS Cecil Field facility.

**Site** The site code identifies a specific area of investigation, such as:

7 = Site 7 at the facility.

**Type** The two-character sample type code identifies the general source type and media of the sample. Codes can include:

MW = groundwater	SD = sediment
SW = surface water	R = equipment rinsate
SC = water supply	T = trip blank
SS = surface soil	SB = soil boring soil sample
OF = organic-free water	MS = monitoring well soil boring sample

**Sample Location and Number** is a number sequence for the exploration (e.g., SB-10). For borings and wells it is important to note that a boring numbered 10 that subsequently may have a monitoring well installed retains the same horizontal locator, number 10.

**Modifier** Examples of modifiers include:

D, duplicate sample;  
S, matrix spike; and  
M, matrix spike duplicate.

Note that the RI field program will continue using the existing sample numbering system for monitoring wells at each site.

**2.8 SAMPLING EQUIPMENT AND PROCEDURES.** Sampling procedures for each sample matrix are outlined in this section. The purpose is to provide specific protocols to the field personnel when performing the work.

**2.8.1 Soil Sampling** Soil samples collected for laboratory analyses will include surface soil samples and split-spoon samples from soil borings.

**2.8.1.1 Equipment** Equipment and materials involved in the collection of soil samples include:

- bound field logbook;
- sample tags and labels and the appropriate forms for documentation;
- appropriate sample containers;
- plastic zip-top bags and sealing tape;
- decontamination equipment and supplies;
- protective clothing and gear;
- appropriate equipment (FID and dustmeter) for breathing zone and sample screening;
- drill rig with hollow stem augers and split-spoon samplers;
- stainless-steel split spoons;
- Shelby tubes;
- glass and/or Teflon™-lined pans, trays, or bowls; and
- stainless steel and/or Teflon™-lined scoops, shovels, trowels, spoons, or spatulas.

**2.8.1.2 Specific Protocols for Surface Soil Sampling** Surface soil samples will be collected in accordance with the procedures discussed below.

1. Put on the personal protective clothing and equipment, as necessary.
2. Place plastic sheeting on a level surface near the sampling area, if possible. Place decontamination equipment and supplies, sampling equipment, sampling containers, and insulated cooler on separate plastic sheeting. Cover all equipment and supplies with plastic sheeting when not in use.
3. Record relevant information in the field logbook. Document sample location, soil description, sample number, and other pertinent information. Soil descriptions will be made in accordance with ASTM D2488.
4. Carefully remove the vegetative cover, if present, before sample collection.

5. Use a clean stainless-steel or Teflon™-lined scoop, trowel, or shovel to obtain a minimum of three sample volumes for the volume needed to fill the specified sample container. Sample depth for surface soil samples will be 0 to 1 foot bls.
6. Fill and cap vials for volatile organic aromatic (VOA) analyses as quickly as possible. Mix remainder of sample directly in a clean stainless-steel or Teflon™-lined tray or bowl. Fill and cap each sample container.
7. Label each sample container with the appropriate information. Fill out chain-of-custody (COC) forms and package samples.
8. Decontaminate sampling equipment in accordance with specified procedures.

**2.8.1.3 Specific Protocols for Subsurface Soil Sampling** A split-spoon sampler will be used to collect subsurface soil samples 6 inches beneath where the surface soil samples were collected. This sampler consists of a stainless-steel, split-steel tube or sample barrel threaded at both ends. A sharpened drive shoe secures the bottom of the barrel and an adaptor secures the top. The adaptor contains a check valve and is threaded to connect directly to the drill rods. The split spoon is driven into undisturbed soil below the casing or hollow stem auger. After the sampler has been driven, it is withdrawn from the borehole and the sampler is opened by removing both drive shoe and adaptor.

Subsurface soil samples will be collected in accordance with the following procedures.

1. Scan the soil with an FID and record the results in a bound field logbook.
2. Visually examine the sample and record its characteristics using the Unified Soil Classification System (USCS) (e.g., texture, color, consistency, moisture content, layering, and other pertinent data). Soil classification will be made in accordance with ASTM D2488.
3. Remove the portion(s) of the sample selected for chemical analyses and place it into appropriate containers using a clean spatula. Soil intended for VOC analyses should be placed in the appropriate containers and capped as quickly as possible. Soil intended for other types of analyses should be placed in a glass mixing bowl and thoroughly mixed using a stainless-steel spoon. Once the sample has been thoroughly mixed, sample material should then be placed in the appropriate sample containers.
4. Discard any excessively disturbed or loose material found in the top portion of the sampler that may not be representative of the interval sampled. This material will be discarded with other boring spoils at each boring location.
5. Properly label all containers and prepare COC forms. Record sample location, sample description, sample numbers, and other pertinent information in the field logbook.
6. Decontaminate the sampling device in accordance with specified procedures.

The sample collector must exercise considerable care while collecting samples for analyses. Methods to assure that high quality samples are collected are described below.

1. Make sure that the sample is obtained from undisturbed soil below the casing or auger. This is accomplished by monitoring or checking the drill crew's measurements, observing the sampling process, and examining the sample once it is retrieved.
2. Carefully remove and discard any portions of the sample that may have become contaminated by contacting the auger.
3. Conserve sample volume, because under certain soil conditions it may be difficult or impossible to achieve good sample recovery with split spoons.

Procedures employed to prevent cross contamination during soil boring sampling operations include the following.

1. Samples are collected immediately after the boring is advanced to the desired sampling depth.
2. The down-hole sampling tools are decontaminated prior to the collection of each sample.
3. The drilling technique and procedures to be used are carefully evaluated for each site.

**2.8.2 Aquaprobe™ Sampling** Screening for potential groundwater contamination will be accomplished by using an *in-situ* groundwater tool called the Aquaprobe™.

**2.8.2.1 Equipment** Equipment and materials involved in the collection of *in-situ* groundwater samples include:

- bound field logbook,
- sample tags and labels and the appropriate forms for documentation,
- appropriate sample containers,
- plastic zip-top bags and sealing tape,
- decontamination equipment and supplies,
- protective clothing and gear,
- appropriate equipment (FID and dustmeter) for breathing zone and sample screening,
- Teflon™ bailer,
- nylon rope,
- drill rig with hollow stem augers,
- stainless-steel drive point,
- 4-foot screened section made of 10 slot wound stainless steel, and

- retractable outer casing that seats against the drive point with a viton o-ring and encloses the screen until the time of sample collection.

**2.8.2.2 Specific Protocols for Aquaprobe™ Sampling** The following procedures will be used when collecting the Aquaprobe™ samples.

1. Auger down 4 to 5 feet above the desired sampling interval.
2. Place the Aquaprobe™ inside the augers with the outer casing firmly seated against the drive point and lower to the bottom of the boring.
3. Advance the probe to the desired sampling interval by hammering (as with a split spoon) or pushing with the drill rig.
4. After the probe has been advanced to the desired sampling interval, retract the outer casing exercising caution not to intersect the hollow stem auger borehole, thereby exposing the screened section to the otherwise undisturbed aquifer.
5. Groundwater will enter the probe through the screen. Collect the sample using a Teflon™ bailer.
6. Following sample collection, remove the Aquaprobe™ from the boring and decontaminate.
7. Continue augering to the next sampling interval and complete the procedure again.
8. Properly label all containers and prepare COC forms. Record sample location, sample description, sample numbers, and other pertinent information in the field logbook.
9. Decontaminate sampling equipment in accordance with specified procedures.

**2.8.3 Monitoring Well Installation and Development** Monitoring wells will be installed at the site to estimate the extent of groundwater contamination. One well in each cluster will be screened at the water table in the UZS, one well will be screened at the bottom of the LZS, and one well will be screened at the top of the UZH.

**2.8.3.1 Equipment** The following equipment or supplies will be used in support of monitoring well installation and development:

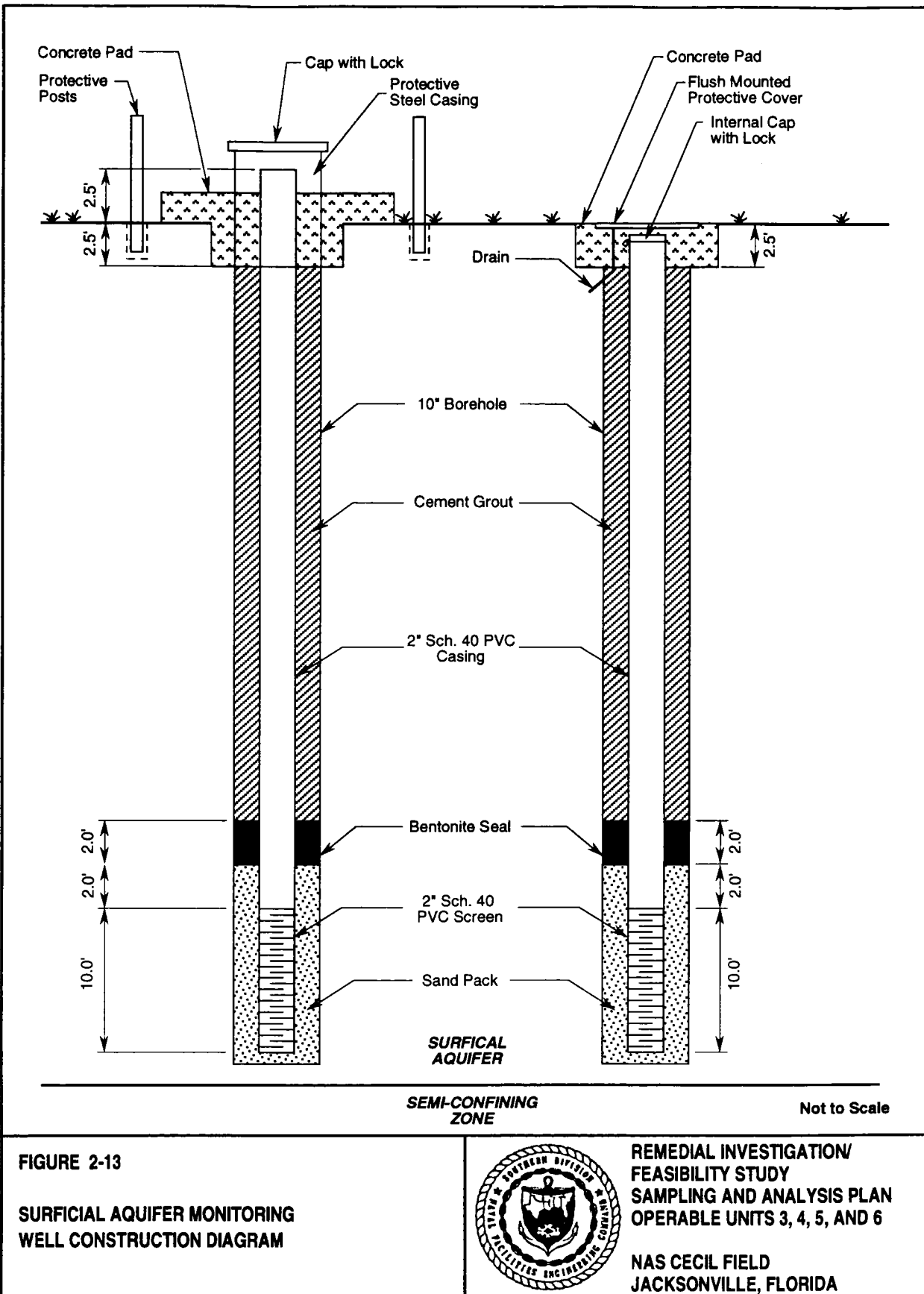
- bound field logbook,
- decontamination equipment and supplies,
- protective clothing and gear,
- appropriate equipment (FID and dustmeter) for breathing zone screening,
- drill rig with hollow stem augers and split-spoon samplers and/or drill rig with dual-wall reverse circulation or reverse circulation (ODEX),

- water level indicator,
- carbon steel surface casing,
- plastic for wrapping well casing and screens,
- clean sand and bentonite, and
- PVC well casing and screens.

**2.8.3.2 Specific Protocols for Monitoring Well Installation** All drilling will be performed in accordance with the applicable ASTM protocols, the ECBSOPQAM (USEPA, 1991), and Navy guidelines (SOUTHNAVFACENGCOM, 1989a; 1989b). The drilling and sampling equipment will be decontaminated prior to drilling each borehole.

**UZS and LZS Monitoring Wells.** The UZS and LZS monitoring wells will be installed as described below. Figure 2-13 depicts a typical well construction diagram for these monitoring wells.

1. To install the UZS wells, a hole using 6.25-inch inner diameter (ID) hollow stem augers will be drilled to a depth 7 feet below the water table. For the LZS wells, augers will be drilled to the bottom of the surficial aquifer. (Determinations of required depth will be based on lithologic samples collected from the UZH wells.)
2. Install a 2-inch diameter, Schedule 40 PVC casing and screen (10-foot length) that complies with National Sanitation Foundation (NSF) Standard 14 through the 6.25-inch ID hollow stem augers to the bottom of the borehole. Backfill the annulus with a sand or filter pack that is rounded, well-sorted, washed, and uniformly sized. A 6-inch layer of sand pack will be placed below the well screen and the sand pack will extend at least 2 feet above the top of the well screen.
3. Develop the well for approximately 30 minutes to ensure proper hydraulic connection with the formation.
4. Seal with bentonite chips at least 2 feet above the sand pack. Let hydrate in accordance with the time period specified by the manufacturer.
5. Seal the remainder of the space with a cement and bentonite grout to the ground surface. Allow the grout to set for 24 hours before continuing work on the well.
6. Set a 4-inch diameter protective steel casing with locking cap into a poured concrete pad graded away from the casing (4 feet by 4 feet by 2.5 feet deep). Insert drain holes in the protective casing immediately above the concrete pad. Note that flush-mounted protective covers will be installed at Site 7 monitoring wells. These wells will be installed in a manner that avoids accumulation of rainwater or runoff by draining to the aggregate below the runway apron pavement. These wells will also be finished with concrete pad constructed level with the ground surface and with locking flush mounted protective covers.



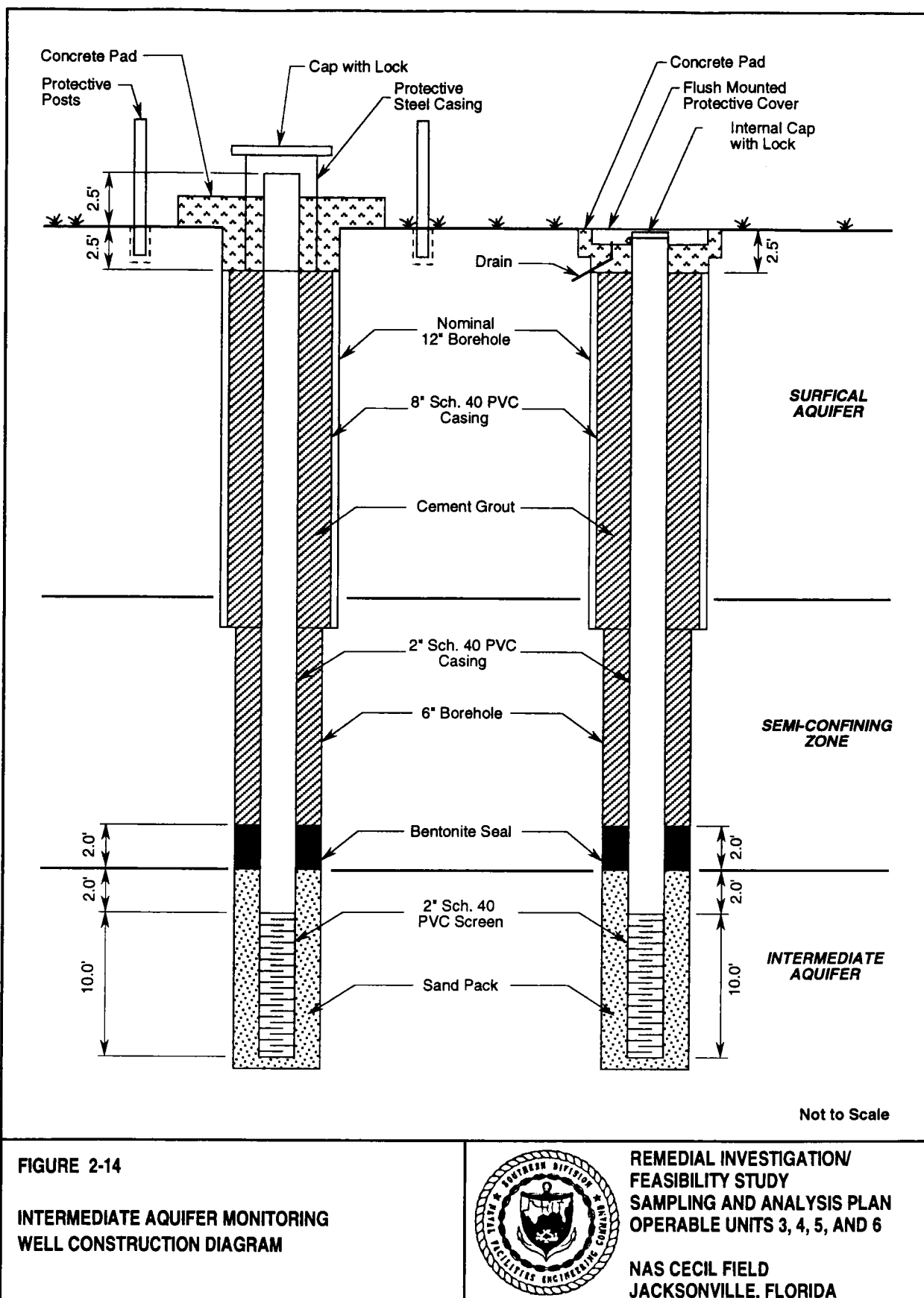
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7. Install four concrete filled bumper posts, primed and painted with high visibility paint, one at each corner and separate from the pad, to a depth of 3 feet below grade and rising 3 feet above land surface.

UZH Monitoring Wells. The UZH monitoring wells will be installed as described below. Figure 2-14 depicts a typical well construction diagram for these monitoring wells.

1. Using either dual-wall reverse circulation or ODEX drilling techniques, drill a nominal 12-inch ID hole, while taking continuous drill cutting samples, until the top of the Hawthorn Group is reached. Drill 2 feet into the semi-confining unit.
2. Remove the tools from the hole and lower an 8-inch, flush-threaded, PVC casing into the hole and grout it into place using the tremie method with a cement and bentonite mixture.
3. Allow the casing and grout to set for a minimum of 24 hours before continuing work on the hole.
4. Lower tools inside the surface casing until they rest on the bottom of the hole. Wash out grout plug with tricone rotary bit. Continue to advance borehole with the dual-wall or ODEX techniques to the bottom of the desired screen interval.
5. Install a 2-inch diameter, Schedule 40 PVC casing and screen that complies with NSF standard 14, 10 feet into the UZH. Backfill from the bottom of the borehole to at least 2 feet above the top of the screen with a sand pack (tremie method).
6. Develop the well for 30 minutes prior to grouting the well. This will ensure that a good connection with the aquifer has been made.
7. Seal with bentonite chips at least 2 feet above the sand pack. Let hydrate in accordance with the time period specified by the manufacturer.
8. Seal the remainder of the space with a cement and bentonite grout to the ground surface. Allow the grout to set for 24 hours before continuing work on the well.
9. Set a 4-inch protective steel casing with locking cap into a poured concrete pad graded away from the casing (4 feet by 4 feet by 2.5 feet deep). Insert drain holes in the protective casing immediately above the concrete pad. Note that flush-mounted protective covers will be installed at Site 7 monitoring wells. These wells will be installed in a manner that avoids accumulation of rainwater or runoff by draining to the aggregate below the runway apron pavement. These wells will also be finished with concrete pads constructed level with the ground surface and with locking flush-mounted protective covers.
10. Install four concrete filled bumper posts, one at each corner and separate from the pad, to a depth of 3 feet below grade and rising 3 feet above land surface.



**2.8.3.3 Well Development** All installed wells will be adequately developed prior to sampling. Monitoring wells will not be developed for at least 24 hours after installation of the protective casing and pad. New monitoring wells will be developed until the column of water in the well is free of visible sediment and the pH, temperature, and specific conductivity have stabilized. Depending on the nature of the soil, wells may be developed for several days, if necessary, to remove formation soil from the well.

Various methods may be used to develop wells at the site. These methods may consist of pumping, bailing, lifting the water column with compressed air, plunging, surging, etc. The exact development method will be left to the discretion of ABB-ES. Periodically, ABB-ES will measure the pH, temperature, specific conductance, and turbidity of water removed during well development to evaluate the adequacy of development. All materials introduced into the wells during development, such as air lines, pumps, etc., will be subject to decontamination procedures.

**2.8.3.4 Well Abandonment** Due to the age and construction characteristics of the existing monitoring wells at Sites 7 and 8 (i.e., 30-foot screens), the existing monitoring wells will be abandoned in accordance with procedures specified by the St. Johns River Water Management District and City of Jacksonville Bioenvironmental Services Division once the initial sampling event monitoring wells have been installed and hydrogeologic data are no longer needed from the existing monitoring wells.

**2.8.4 Groundwater Sampling** Groundwater samples for laboratory analyses will be collected from newly installed monitoring wells. The purging and sampling techniques outlined below help ensure the collection of a representative sample.

**2.8.4.1 Purging Technique** Wells will be purged before groundwater sampling to remove stagnant water so that a representative sample may be obtained. At least three to five well volumes will be pumped if the well responds to the purging. Purging will proceed at flow rates that result in low turbidity and small (less than 1 foot) differential head. Sampling will occur as soon as possible after the purge is completed. If the well purges dry, it will be sampled within 24 hours after pumping, provided adequate water exists for sampling.

Purging equipment includes:

- pump, tubing, Teflon™ bailer, and line;
- power source (e.g., generator), if required;
- water level meter or weighted surveyor tape;
- pH, temperature, and conductivity meter;
- turbidity meter;
- personal protective equipment;
- Teflon™ leader;
- nylon line;
- decontamination supplies; and
- disposal drums, if required.

**Volumetric Method of Well Purging.** The procedures to follow when purging the monitoring wells are discussed below.

1. Open well cover and check condition of the well head.

2. Determine volume of water in well by measuring distance from the bottom of the well to the static water level (height of standing water), then measure the inside diameter of the well or casing. Water level measurements to the nearest 0.010 foot will be taken. The same reference mark will be used for subsequent water level measurements. Note: more stringent measurements may be required for specific projects.

3. Calculate well volume by using the following formula (or its equivalent):

$$V = 0.041d^2h \quad (1)$$

where

v = volume of water in gallons,  
d = inside diameter of well in inches, and  
h = height of standing water column in feet.

4. Prepare pump and tubing, or bailer, and lower it into casing.
5. Set up probes of indicator meters at the discharge outlet of the pump or in a clean beaker. Allow probes to equilibrate according to manufacturers' specifications.
6. Remove five well volumes. Record indicator parameter readings (pH, specific conductance, temperature, and turbidity) at regular intervals. Pumping should continue until indicator parameter readings remain stable within  $\pm 10$  percent for two consecutive recording intervals (5 minutes apart) and at least three well volumes have been purged.
7. Record pertinent data in field logbook.
8. Remove pump assembly or bailer from the well and decontaminate as required.
9. Dispose of liquid IDW per procedures specified in the *Investigation-Derived Waste Management Plan* (ABB-ES, 1994).
10. Note: All fuel-powered units will be placed away from and downwind of any site activity (purging, sampling, etc.)

Whenever possible, monitoring well purging should be accomplished with a pump. To prevent backflow of purged water into wells, submersible pumps must be equipped with a check valve, and centrifugal pumps must have a foot valve. When sampling for organics or metals, certain precautions must be taken to minimize the risk of contaminating the groundwater sample with the pump. In general, any parts of the pump and tubing that contact the groundwater must be constructed of Teflon™ or stainless steel.

**2.8.4.2 Specific Protocols for Groundwater Sampling** Where possible, sampling of monitoring wells will proceed from the upgradient (background) wells to the downgradient (or potentially contaminated) wells.

Groundwater sampling equipment includes:

- bailers constructed of appropriate material (Teflon™) with a Teflon™ coated, stainless-steel leader;

- clean (nylon twine or monofilament) line of sufficient length to lower bailer (new lanyard must be used for each well);
- a pump (type dictated by physical conditions);
- appropriate sample containers with labels and preservatives, as required;
- coolers with wet ice;
- water level meter and/or other water level measuring device;
- plastic sheeting;
- decontamination supplies, as required; and
- personal protective clothing and equipment, as required by the site-specific HASP.

Groundwater sampling procedures include the following steps.

1. Put on protective clothing and equipment, as necessary.
2. Prepare the location for sample collection by covering the ground surface around the well head with plastic sheeting.
3. Open well and note condition of casing and cap. Check for vapors using an FID.
4. Determine static water level using a water level meter or tape. Depth to well bottom is recorded prior to the sampling event for all monitoring wells at a specific site. This information is then used to calculate the water column in each monitoring well prior to sampling. Record this information in the field logbook.
5. Determine purge volume and purge the well.
6. Arrange sample containers in order of use. VOA samples will be taken first, followed in order by metals, SVOCs, and other samples. If after purging, the turbidity reading is greater than 5 NTU, filtered metals samples will also be collected.
7. Lower bailer or pump intake into well. Bailer should enter the water slowly to prevent aeration.
8. Collect the samples.
  - Fill the VOA samples directly from the first Teflon™ bailer of groundwater removed from the well after purging with as little agitation as possible. Fill each vial until the sample forms a convex meniscus above the top edge of the vial, and then carefully cap the vial. Invert VOA sample bottles and tap to check for air bubbles.
  - Fill the metals bottle with the remaining groundwater in the first bailer after VOA samples have been collected.

- Other samples will be placed directly in the appropriate container from the discharge tubing of the pump or Teflon™ bailer.
  - If the turbidity at the completion of purging is greater than 5 NTUs, filter the appropriate samples to be analyzed for TAL parameters.
9. Add preservative (if needed), cap, seal, and properly label all containers. Place filled containers into the cooler(s) immediately.
  10. Record sample types and amounts collected and time and date of collection in the field logbook. Prepare COC forms. Prepare samples for shipment to the laboratory.
  11. Decontaminate sampling equipment and dispose of lanyard.

**2.8.5 Aquifer Testing and Measurement** Slug tests will be conducted in each new monitoring well to estimate the horizontal hydraulic conductivity of the aquifer media. In addition, each new monitoring well will be surveyed vertically and horizontally by a surveying subcontractor. One round of groundwater level measurements will then be collected from each new and each existing monitoring well to evaluate the groundwater flow pathways.

**2.8.5.1 Equipment** The following equipment or supplies will be used in support of this task:

- two-channel data logger with pressure sensitive water level transducers,
- lap-top field computer with printer,
- aquifer test data reduction software,
- water level or measuring tape,
- field logbook,
- slug of known volume,
- decontamination solutions and equipment, and
- personal protective gear and monitoring instruments.

**2.8.5.2 Specific Protocols** Procedures to be followed during aquifer testing and measurement are discussed below.

**In-Situ Hydraulic Conductivity Testing.** Slug testing will be conducted by following the procedures presented below.

1. Record static water levels.
2. Install water level transducer in monitoring well.
3. Introduce slug into well.
4. Allow water level to stabilize.
5. Set reference on data logger.
6. Instantaneously remove slug and activate data logger.
7. Allow water level to stabilize.
8. Record data.
9. Decontaminate equipment and mobilize to next well.

**Monitoring Well Surveying.** A Florida-registered land surveyor will survey the north side of the top of casing (riser) and ground surface for all newly installed monitoring wells for both horizontal and vertical control to a minimum degree of accuracy of 0.1 and 0.01 foot, respectively. The surveying subcontractor will

use the registered U.S. Geological Survey (USGS) benchmark nearest the site. Survey points will be referenced to the state planar coordinates and the National Geodetic Vertical Datum of 1929.

**Water Level Measurements.** Water levels will be permitted to stabilize a minimum of 24 hours prior to recording water level elevation measurements. All water level measuring activities will be performed within the shortest period of time possible to minimize the influence of barometric pressure. Each measurement will be made from a known point of elevation marked on the well casing, as surveyed by a licensed surveyor. The following steps will be taken.

1. Calibrate and decontaminate equipment and mobilize to first location.
2. Measure static water level and reference to the surveyed point.
3. Decontaminate equipment.
4. Proceed to next location.

**2.8.6 Surface Water and Sediment Sampling** Surface water and sediment samples will be collected at Sites 8, 10, 14, and 15.

**2.8.6.1 Equipment** The following equipment will be used during this activity:

- field logbook;
- sample containers;
- sample packaging and shipment equipment;
- stainless-steel spoons, dredge corer, or hand auger;
- Pyrex™ bowls;
- pH, temperature, and conductivity meter;
- dissolved oxygen meter;
- sampling shipping material;
- sample seals;
- sample tags;
- decontamination solutions and equipment; and
- protective gear and air monitoring equipment.

**2.8.6.2 Specific Protocols for Surface Water Sampling** The following procedures will be followed when collecting surface water samples.

1. With sample bottles immediately available, don uncontaminated gloves.
2. The following guidelines will be considered in selecting representative sampling points.
  - Avoid collecting samples immediately above or below the confluence of streams.
  - The most downstream location should be sampled first and the most upstream location last.
3. If it is necessary to wade into the water, the team member will be careful not to disturb bottom sediment at the sample collection point by approaching the sample collection area from downstream.

4. Samples will be collected at mid-depth from the center of the stream channel and placed directly into the sample containers with the sample bottles oriented with the opening facing upstream.
5. Measure and record in the logbook the pH, conductivity, temperature, and dissolved oxygen of the surface water. These measurements may be taken from the water body itself or from a sample collected in an additional container, if necessary. All instrument calibration will also be recorded in the logbook.
6. Filter the appropriate samples to be analyzed for TAL parameters.
7. Add chemical preservatives to metals and cyanide sample containers. Note that the aqueous VOA containers will be pre-preserved before sampling.
8. Complete documentation for the sample.
9. Attach custody seals and place samples in a plastic bag.
10. Identify, package, and ice samples for shipment.
11. The entire sampling process will be documented in the field logbook.

**2.8.6.3 Specific Protocols for Sediment Sampling** The following procedures will be followed when collecting sediment samples.

1. The following guidelines will be considered in selecting representative sampling points.
  - In flowing water, sediment deposition typically occurs inside river bends on point bars, downstream of islands or other obstructions.
  - Avoid collecting samples immediately above or below the confluence of streams. Allow sufficient distance for the sediment to mix.
  - Sediment samples will be collected from depositional areas as opposed to scoured areas as practical.
  - The most downstream location should be sampled first and the most upstream location last.
2. If it is necessary to wade into the water, the team member will be careful not to disturb bottom sediments at the sample collection point by approaching the sample collection area from downstream.
3. Depending on the character and accessibility of the sediment, a stainless-steel spoon, dredge, corer, or hand auger will be used to collect the samples.
4. With Pyrex™ bowl and sampling equipment immediately available, don uncontaminated gloves.
5. Collect sediment samples while facing upstream and deposit the sediment into a Pyrex™ bowl.

6. Transfer VOA samples to sample jars and apply specified closure.
7. Homogenize the sediment in the Pyrex™ bowl with a stainless-steel spoon.
8. Transfer sediment to sample containers and identify samples with completed sample tags.
9. Attach COC seals and place samples in a polyethylene bag.
10. Identify, package, and ice samples for shipment.
11. The entire sampling process will be documented in the field logbook.

### 3.0 QUALITY ASSURANCE PROJECT PLAN

3.1 PROJECT ORGANIZATION AND RESPONSIBILITIES. The project organization is depicted on Figure 3-1. The organizational structure acts as a control mechanism to:

- identify appropriate lines of communication and coordination;
- monitor overall project quality control, budgets, and schedules;
- oversee and manage technical resources; and
- monitor health and safety.

3.2 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT. Parameters used within the data validation process to evaluate data quality include measurement of precision, accuracy, representativeness, completeness, and comparability (PARCC). The achievable limits for these parameters vary with the DQO level of the data. These parameters are defined here and methods of calculation are discussed in Section 3.11. The QA objectives for the proposed analytical methods are presented in the USEPA CLP statements of work (USEPA, 1990).

Precision and Accuracy. Precision, the ability to replicate a value, and accuracy, the ability to obtain a true value, are addressed for all generated data. Precision and accuracy requirements vary depending on intended data uses and are selected in accordance with project requirements. DQOs for precision and accuracy are established for each major parameter to be measured at the site based on knowledge of the capabilities of available measurement systems and the analytical detection limit required.

Representativeness. Representativeness expresses the degree to which sample data depict an existing environmental condition. Representativeness is accomplished through proper selection of sampling locations and sampling techniques and collection of a sufficient number of samples.

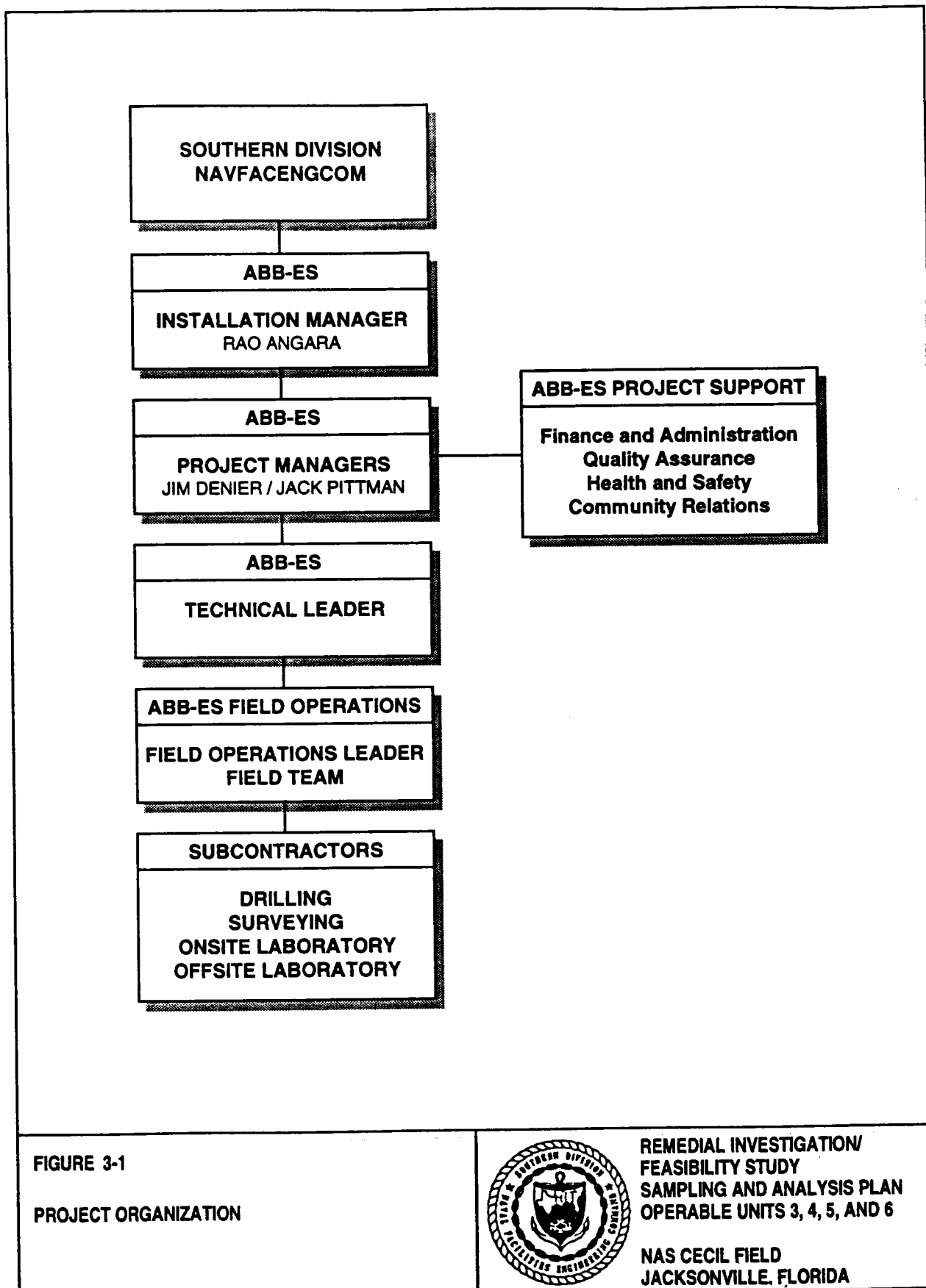
The sampling locations in this RI will be chosen in a biased approach based on previous analytical data, screening data collected in the field, and apparent and measured flow directions.

Sampling and analytical protocols were chosen so that measurements of samples will be as representative of the media and conditions being measured as possible.

Sample collection, handling, and documentation will be performed in accordance with the ECBSOPQAM (USEPA, 1991) to ensure that collection and handling techniques do not alter the sample and to provide an adequate tracking mechanism from the time of collection through laboratory analyses.

Completeness. The characteristic of completeness is a measure of the amount of valid data obtained compared to the amount of data originally intended to be obtained. The completeness goal for DQO Levels III and IV will be consistent with the CLP requirements of 95 percent.

Field activities performed at DQO Levels I and II are onsite measurement techniques that provide information in real time or after minimal delay. The completeness achieved for these methods may be more variable than those for



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standard analytical methods. A higher degree of completeness may be achieved because measurements can be readily repeated. However, site conditions may constrain the use of some techniques, resulting in fewer valid analyses than anticipated.

The sampling objectives described in these planning documents allow for a sufficient number of samples to accomplish the project objectives. However, the number of samples presented are estimates that may be revised based on screening data collected in the field. Examples of circumstances that may cause variations might include increasing or decreasing the number of samples needed for adequate delineation or characterization of IDW, and/or decreasing the number of screening samples.

Comparability. The characteristic of comparability reflects the confidence with which one data set can be compared with other measurements and the expression of results consistent with other organizations reporting similar data. This will be accomplished through the use of standard techniques for sample collection analyses and the reporting of results in appropriate units. Comparability of analytical procedures also implies using analytical methodologies that produce results comparable in terms of precision, accuracy, and effective range of calibration.

3.3 SAMPLING PROCEDURES. Step-by-step instructions for each type of sampling activity are necessary to enable the field team to gather data that will meet the DQOs. Sampling procedures for each sample matrix are outlined in the FSP (Chapter 2.0).

3.4 SAMPLE CUSTODY. Each sample received by the analytical laboratory for processing must be properly documented to ensure complete and accurate analyses for all parameters requested.

3.4.1 Chain of Custody After the sample is collected, the outside of the sample container is properly decontaminated and documentation for sample shipment is completed, a COC record must be prepared to maintain the legal transfer of the sample from the field team to the laboratory. The COC lists each sample in that shipment. The COC record is used to record the custody of samples and will accompany samples at all times. Procedures for maintaining the appropriate sample custody information will be in accordance with the ECBSOPQAM (USEPA, 1991). The COC record will contain the following information:

- project name,
- signature of samplers,
- sampling station number or sample number,
- date and time of collection,
- brief description of the type of sample and sampling location,
- analyses to be performed and sample bottle type,

- for each sample, the number of containers for each bottle type,
- signatures of individuals involved in sample transfer (i.e., relinquishing and accepting samples),
- sample label number, and
- matrix.

All samples will be accompanied by the COC record. The original and one copy of the record will be shipped inside the shipping container if samples are shipped. By using a unique sample identification number for each sample, all ancillary records can be traced to specific sampling events. One copy of the COC record will be retained by the field investigator. The original record will be transmitted to the field investigator after samples are accepted by the laboratory. This copy will become part of the project records. The COC record will be signed and dated upon receipt by the laboratory. Custody tracking will be maintained by the laboratory from sample receipt through storage, analyses, and disposal in accordance with the individual laboratory's QA plan. Figure 3-2 shows an example of a typical COC record.

When samples are relinquished to a shipping company for transport, the tracking number from the shipping bill or receipt will be recorded on the sample COC record. As necessary, ABB-ES uses carriers (i.e., Federal Express) to ship samples. In these cases, the airbill becomes part of the COC.

**3.4.2 Sample Labels** Samples, other than those collected for field measurements or analyses, are identified by using a standard sample label that is attached to the sample container. The following information is included on the sample label:

- site name,
- field identification or sample station number,
- date and time of sample collection,
- designation of the sample as a grab or composite,
- the signature(s) of the sampler(s),
- sample preservation and preservative used, and
- the general types of analyses to be conducted.

Figure 3-3 shows an example of a sample label.

**3.4.3 Handling, Packaging, and Shipping Requirements** After the sample labels are affixed to the sample container and the COC record is completed, shipping containers can be prepared.

Sample packaging and shipping procedures should protect the integrity of the samples and prevent detrimental effects from leakage or breakage. Regulations for packaging, marking, labeling, and shipping hazardous materials and wastes are promulgated by the U.S. Department of Transportation (DOT) and described in the Code of Federal Regulations (49 CFR 171 through 177; in particular 172.402h, Packages Containing Samples). In general, these regulations were not intended to hamper shipment of samples collected at controlled or uncontrolled hazardous waste sites or samples collected during emergency responses. However, the USEPA has agreed through a memorandum of agreement to package, mark, label, and ship samples observing DOT procedures.

### FIGURE 3-2

#### CHAIN-OF-COSTODY RECORD



**REMEDIAL INVESTIGATION/  
FEASIBILITY STUDY  
SAMPLING AND ANALYSIS PLAN  
OPERABLE UNITS 3, 4, 5, AND 6**

**NAS CECIL FIELD  
JACKSONVILLE, FLORIDA**

Client: _____ _____ Date: _____ Sample Site: _____ _____ Sampler: _____ Preservative: _____ Filtered: _____	
--	--

(Actual Size: 2" x 3")

**FIGURE 3-3**

**SAMPLE LABEL**



**REMEDIAL INVESTIGATION/  
FEASIBILITY STUDY  
SAMPLING AND ANALYSIS PLAN  
OPERABLE UNITS 3, 4, 5, AND 6**

**NAS CECIL FIELD  
JACKSONVILLE, FLORIDA**

Prior to packaging, each sample container should be inspected to verify correct labeling. Labels should be secured to containers with clear tape. Samples will be shipped to the laboratory via commercial ground or air carrier within 24 hours of sample collection.

All breakable sample containers (glass) will be protected with packing. Bubble-pack bags or strips are acceptable. Sample containers may be placed together in heavy duty garbage bags and sealed.

Samples will be shipped in durable coolers packed with bubble-pack or vermiculite. Samples will be kept cool with double-bagged clean ice. Completed COC records will be placed in a plastic bag and taped to the inside lid of the shipping container. If COC records refer to multiple containers, they will be placed in the lead container.

A signed and dated COC seal will be secured with clear tape over the front of the container lid. The container will be sealed by wrapping it in filament tape.

Until relinquished to the carrier, the shipping containers are to remain with ABES personnel or remain in a locked vehicle so as not to be accessible to others. Upon shipping, the laboratory will be contacted and advised of the contents, arrival date and time, carrier, and number of containers.

3.5 CALIBRATION PROCEDURES. Procedures and documentation required for calibration of field instruments and laboratory instruments and equipment are contained in the ECBSOPQAM (USEPA, 1991) and USEPA CLP procedure manuals for organic and inorganic analyses. It should be noted that some of the calibration and maintenance procedures specified in the ECBSOPQAM are specific to the Environmental Control Branch operations and are not applicable to Cecil Field IR operations.

Field instruments and equipment will be calibrated and inspected daily before field activities begin, as suggested by the manufacturers. Calibration information will be recorded in a calibration log, which will be kept on file at the field office trailer. Malfunctioning instruments will be repaired or replaced. Monitoring equipment will be protected from contamination during field exploration activities as much as possible without hindering operation of the unit. Equipment maintenance will be performed according to manufacturer specifications before field use, or by cycling units out of the field. As appropriate, routine periodic maintenance may be performed as a function of field calibration. Calibration and maintenance information for the field equipment to be used during the RI investigation can be found in Appendix B. Where the requirements found in the ECBSOPQAM, manufacturers' instructions, and procedures found in Appendix B conflict, the most rigorous will apply.

All offsite laboratories will have an in-place program for equipment calibration procedures and frequency that meets standards established by the USEPA CLP. The onsite laboratory to be used during the investigation will use approved SOPs for analyzing samples (Pace Inc., 1992a; 1992b; 1992c; 1994a; 1994b; 1994c) and will apply calibration procedures and frequencies specified by USEPA.

**3.6 ANALYTICAL PROCEDURES.** Laboratory analytical procedures will be conducted in conformance with USEPA CLP requirements. Sample matrices and types to be collected and analyzed are specified in Chapter 5.0 of the workplan. An onsite laboratory will be used to obtain quick turnaround data to help guide the field investigation. The onsite laboratory will use approved SOPs for analyzing samples (Pace Inc., 1992a; 1992b; 1992c; 1994a; 1994b; 1994c). An offsite laboratory will also be used for confirmatory purposes. Laboratory analytical samples will be collected and analyzed in conformance with Level III and Level IV DQOs and the ECBSOPQAM (USEPA, 1991). The subcontracted laboratories will have an active internal QA/QC program and will be NEESA approved.

The analytical parameters are proposed based on suspected and identified waste types as discussed in the workplan. A list of the sample types, parameters, and methods to be used by all laboratories supporting this RI/FS program is provided in Table 3-1.

**3.7 DATA REDUCTION, VALIDATION, AND REPORTING.** Data collected from investigative activities include survey data, field screening data, and onsite and offsite laboratory analytical data. The ultimate data uses include site characterization, the assessment of potential risk to human health and the environment, and the development of effective remedial measures, where necessary.

Upon receipt of samples for analyses (accompanied by a completed COC record detailing requested analyses), both the onsite and offsite laboratories will:

- verify all COC records;
- log in samples, assign unique log numbers, and attach numbers to the sample containers;
- open project file and enter data on laboratory computer;
- assign priority and hazard rating criteria; and
- store samples in refrigerated sample bank.

Samples will be analyzed by chemists and/or technicians using approved analytical procedures presented in Section 3.6. The chemist or technician will then record the results of analyses and detail all procedural modifications, deviations, or problems associated with the analyses in a parameter workbook.

**3.7.1 Field Screening Data** Screening data will include results from the geophysical survey of Site 10, soil and groundwater sample screening with an FID at discrete depths, air quality monitoring, and field parameter (pH, temperature, specific conductivity, and turbidity) measurements.

Screening activities allow real-time or rapid analyses of contaminant distribution or of indicator parameters that may correlate with the presence of contamination. This information is useful for site characterization and for determining strategic sampling locations. QC procedures used with qualitative screening instruments (e.g., pH meter, FID, etc.) include calibration and comparison of results.

**Table 3-1**  
**Laboratory Analytical Methods**

Remedial Investigation and Feasibility Study Sampling and Analytical Plan  
Operable Units 3, 4, 5, and 6  
NAS Cecil Field, Jacksonville, Florida

Matrix	Parameter	Method Reference
Onsite laboratory: Soil	PAHs (Sites 7 and 8 only)	USEPA Method 8270
	TPH (Sites 7 and 8 only)	USEPA Method 418.1
Groundwater (Aquaprobe™)	VOCs and naphthalene (subsurface soil only at Sites 7 and 8)	Modified USEPA Methods 8010/8020
	TNT (Sites 14 and 15 only)	USEPA Draft Field Method 8515
Offsite laboratory: All media	VOCs and naphthalene	Modified USEPA Methods 8010/8020
	TPH (Sites 7 and 8 only)	USEPA Method 418.1
Offsite laboratory: All media	TCL compounds (all sites)	CLP SOW No. OLM01 with all revisions
	TAL compounds (all sites)	CLP SOW No. ILM03 with all revisions
	Nitroaromatic compounds (Sites 14 and 15 only)	USEPA Method 8330
	Additional pesticides/herbicides (Site 11 only)	USEPA Methods 8150, 8140, and 1,2-dibromo-3-chloropropane
Offsite laboratory: All media	Lead (soil only at Sites 7 and 8)	USEPA Method 6010
<p>Notes: PAH = polynuclear aromatic hydrocarbon. USEPA = U.S. Environmental Protection Agency. TPH = total petroleum hydrocarbon. VOC = volatile organic compound. TNT = 2,4,6-trinitrotoluene. TCL = target compound list. CLP = Contract Laboratory Program. SOW = statement of work. TAL = target analyte list.</p>		

**3.7.2 Laboratory Data and Validation** DQO Level IV laboratory analyses will be in conformance with USEPA CLP requirements. Upon receipt, only DQO Level IV analytical data will be systematically validated in conformance with USEPA *Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses* (USEPA, 1988c) and *Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (USEPA, 1988b). These guidelines provide a systematic procedure for evaluating laboratory QA/QC measures such as holding times, blank analyses, surrogate recoveries, matrix spike results, GC/MS tuning, instrument calibration, compound identification, and method performance. PARCC parameters will be evaluated during validation of the laboratory analytical results, as described in Section 3.11.

Validated data will be prepared in three initial formats: raw laboratory data, data marked with validation qualifiers or annotations, and validated data. The validated data can then be used for contaminant characterization and assessment at each site. A validation summary of the data will be included as part of the RI reports.

Greater variability may be expected from field screening methods and, due to time constraints, the field screening data will not be formally validated. However, the data will be generally evaluated for accuracy. Records of field QA/QC data will be maintained, out-of control conditions will be noted, and, where appropriate, the data will be rejected or annotated.

**3.7.3 Data Management** These requirements were developed to provide a standardized reporting system for locating and tracking environmental data. A data management system that includes maintaining field logs, sample management and tracking procedures, and document control and inventory procedures for both laboratory data and field measurements will be implemented to ensure that the data collected during the investigation are of adequate quality and quantity to support the risk assessment and FS. Data will be stored in an automated computer data management system with hard copy backup.

**3.7.4 Data Evaluation** Chemical and physical data collected during the RI will be used to characterize the sites and to evaluate the potential levels of risk posed to human health and the environment. Physical and chemical data will be integrated to form a conceptual overview of each site.

Data will be summarized and plotted on scaled maps to facilitate the analyses of contaminant distribution and potential mechanisms of transport. Chemical data will be compared to applicable or relevant and appropriate requirements (ARARs) and contaminants of potential concern will be identified.

Physical and chemical data will be evaluated to determine the distribution of contaminants, contaminant interactions, transport mechanisms, and potential fate. This includes an evaluation of: groundwater transport, groundwater-surface water interactions, surface water transport, vadose zone transport, volatilization, soil erosion, retardation, degradation, and transformation. The evaluation of the factors listed above will be subject to the availability of sufficient experimental and empirical reference data.

Plausible exposure pathways and exposure scenarios will be evaluated to assess potential levels of risk posed by the contaminants of potential concern. The risk

assessment is based on an evaluation of exposure patterns, available toxicity data, and dose-response relationships.

Ultimately, the data collected will be evaluated to support no further action or remedial action decisions, treatability studies, and remedial design.

**3.7.5 Evaluation of Data Gaps** All data will be continually assessed and each site will be evaluated to determine: (1) if contamination is present, (2) if it presents a threat, (3) if it has been defined, and (4) what further action is needed (i.e., delineation, interim or early remedial action, or evaluation of remedial alternatives). The goal is to eliminate lengthy interim report development and review times by allowing continual data assessment and rapid decision making.

**3.8 INTERNAL QUALITY CONTROL.** Internal QC procedures are designed to assure the consistency and continuity of data. The frequency of QC checks is based on the type of QC analyses. Standard sample QC analyses include, but are not limited to, duplicate samples, equipment rinsate blanks, trip blanks, matrix spike and matrix spike duplicate samples, and field water blanks. All QC samples will be analyzed by the offsite laboratory performing CLP analyses at DQO Level IV. Only duplicate samples and field blanks will be analyzed by the onsite laboratory. QC samples will be analyzed for the same parameters as the environmental samples collected during the site-specific sampling event except for trip blanks, which will be analyzed for TCL volatile organics only. Each of these types of QC samples is explained below. An estimate of the number and types of QC samples to be collected during the RI is included in Table 5-1 of the workplan.

Other internal QC activities are undertaken during the performance of work to ensure that the service, designs, and documents produced meet currently accepted professional standards. Small assignments or tasks entail periodic discussions among the technical staff, the Project Manager, and Program Manager. QC on larger assignments may require professional review teams and/or internal audits.

**Duplicate Samples.** Duplicate samples are two or more samples collected simultaneously into separate containers from the same source under identical conditions. One duplicate will be collected for every 10 samples of a single matrix (from a single site). Duplicate samples are intended to assess the homogeneity of the sampled media and the precision of the sampling protocol.

**Trip Blanks.** Trip blanks are prepared by the laboratory prior to the sampling event and accompany empty sample bottles to the facility when samples are collected. The trip blanks are kept with the investigative samples throughout the sampling event and are packaged and shipped with the investigative samples. These containers should never be opened prior to laboratory analyses. One trip blank will be included with each shipment of samples scheduled for VOC analysis. Trip blanks are required for assessing the potential for contaminating samples with VOCs during sampling or in transit.

**Equipment Rinsate Blanks.** Equipment rinsate blanks are collected by running organic-free water over and/or through sample collection equipment after it has been decontaminated. Equipment rinsate blanks will be collected at a frequency of one per day or one per decontamination event. These blanks are used to assess

the adequacy of decontamination procedures and to trace potential cross contamination.

Matrix Spike and Matrix Spike Duplicates. Matrix spike and matrix spike duplicate samples are additional samples collected in the field from a single sampling location. These samples are spiked in the laboratory with a known compound (or set of compounds) of known concentration. The concentration detected, after analyses, provides an estimate of the amount of compound "lost" (e.g., sorbed to glassware, volatilized, degraded, etc.) during the analytical procedure. A comparison of the original concentration to the final concentration provides data concerning analytical precision and accuracy. One set of matrix spike and matrix spike duplicate samples will be collected per 20 samples per matrix.

Field Water Blanks. Field water blanks include a complete set of samples collected from each water source used in the investigation. One set of samples will be collected from each water source used at the beginning of the project and one set at the completion of the project. Samples may be collected in the middle of the project if deemed necessary. These samples should account for potential artifacts that could be introduced through decontamination procedures. Samples of the preservatives will also be collected as part of the collection and preservation of field blanks of the organic free water source.

Materials Blanks. Materials blanks include a complete set of samples collected from each material used in the construction of monitoring wells. Samples will be collected from filter pack sand, grout, and bentonite chips. One set of samples will be collected from each source material used at the beginning of the project and one set at the completion of the project. Samples may be collected at any time during the project if deemed necessary. These samples should account for potential artifacts that could be introduced during the monitoring well construction procedures.

3.9 PERFORMANCE AND SYSTEMS AUDITS. Audits are performed to verify that work being completed within the RI/FS program complies with QA program goals. Internal ABB-ES audits of laboratory subcontractors are routinely conducted and subcontracted laboratories must be CLP qualified and NEESA approved.

System audits may be conducted on system components to evaluate appropriate selection and utilization. The project system audit includes evaluation of field, office, and laboratory procedures. System audits may address the following components:

- organization and personnel,
- facilities and equipment,
- analytical methodology,
- sampling and sample handling procedures, and
- data handling.

All primary documents will receive internal technical reviews and a minimum of one internal audit will be scheduled for the RI/FS field program. Technical reviews and internal audits will be performed in accordance with the ABB-ES Comprehensive Long-term Environmental Action, Navy (CLEAN) Quality Assurance Program Plan. A minimum of one internal audit will be scheduled by the Quality Assurance Manager (QAM) in coordination with the Task Leader during the RI/FS

activities. All audit records, including audit plans, reports, written responses, and corrective action forms, will be maintained with the project files.

**3.10 PREVENTIVE MAINTENANCE.** Preventive maintenance for laboratory equipment and instruments will be performed in accordance with CLP requirements and the individual laboratory QA/QC program. An inventory control system including all field equipment and instrumentation used by ABB-ES personnel will be maintained by the equipment manager as the basis for maintenance and calibration control. Maintenance procedures for the field equipment to be used during the RI investigation are included in Appendix B.

Problem prevention can be applied to all phases of project implementation. The key to preventing and resolving problems is careful advanced planning and close communications between management and technical personnel in both client and contractor organizations. Problems will be anticipated and prevented by undertaking the following measures:

- identifying possible problems that have a high probability of occurrence of a potentially significant negative impact on performance (e.g., quality of services performed, schedules, and costs);
- identifying events, observations, or other signals possibly indicative of a developing problem;
- identifying the organizational level most likely to recognize a developing problem and the level with authority to react to the problem;
- developing preventive measures for avoiding or reducing the impact of a problem that preferably can be implemented at the same organizational level at which the problem is recognized; and
- communicating the information generated in the preceding steps to appropriate staff.

**3.11 DATA ASSESSMENT PROCEDURES.** The assessment of data measurements is an activity that affects data quality. Procedures to be used for calculating PARCC parameters are discussed below.

**3.11.1 Parameters for Level III and IV DQOs** The acceptance criteria for PARCC parameters for Level III and Level IV DQOs are defined by the CLP guidelines and by the laboratory analytical methods chosen. CLP contract required quantitation limits (CRQLs) will be requested for laboratory analyses.

**Precision.** Laboratory analytical precision is a quantitative measurement of reproducibility. Precision is the variability of a group of measurements compared to their average value, monitored and evaluated on this project through comparison of duplicate samples (including matrix spike duplicate samples).

Precision is a parameter evaluated during the data validation process. Precision will be calculated as Relative Percent Difference (%RPD) using the formula:

$$\% RPD = \frac{D_1 - D_2}{(D_1 + D_2) / 2} \times 100 \quad (2)$$

where

%RPD = relative percent difference,

D<sub>1</sub> = first sample value, and

D<sub>2</sub> = duplicate sample value.

Field and laboratory measurement precision will be established by the collection and analyses of field and laboratory duplicate samples. Ten percent of the field samples will be collected in duplicate. Laboratory duplicates will be prepared in accordance with CLP statement of work (SOW) requirements or guidance stated in specific testing methods, as appropriate. Although a quantitative goal cannot be set due to field variability, field duplicate %RPD values will be reviewed to estimate precision. The values listed in Table 3-1 will be used to evaluate field duplicate %RPD values.

Accuracy Accuracy is the quantitative measurement of the bias of a system, relating a reported sample concentration to its actual value. Analytical accuracy is quantified by calculation of "spike" recovery. In the laboratory an aliquot of either a surrogate or a specific target compound(s) (i.e., spike), at known concentrations, is added to the sample. The concentration of the recovered spike is compared to the original concentration added and expressed as a percent recovery (%R). This measurement provides an estimate of the percentage loss of a given compound during analyses (e.g., loss due to sorption to glassware, volatilization, degradation, etc.). The percent recovery is calculated by the formula:

$$\% R = \frac{SSR - SR}{SA} \times 100 \quad (3)$$

where

%R = percent recovery,

SSR = spike sample results,

SR = sample results, and

SA = spike added from spiking mix.

The comparison of matrix spike and matrix spike duplicate samples to the original sample, as well as calculation of surrogate recoveries in original samples, will be used to measure accuracy. Accuracy for laboratory measurements will be in accordance with CLP SOW requirements or guidance stated in specific testing methods, as appropriate.

Completeness. Percent completeness (%C) is the number of valid measurements collected compared to the number of samples collected for analyses. Valid measurements refer to data validated in conformance with USEPA CLP guidelines. It is calculated by the formula:

$$\% C = \frac{N_A}{N_1} \times 100 \quad (4)$$

where

%C = percent completeness,  
N<sub>A</sub> = actual number of valid measurements, and  
N<sub>1</sub> = number of samples collected.

Completeness will be ensured by collecting an adequate number of samples to meet project objectives. A completeness goal of 95 percent will be established for chemical results.

Representativeness and Comparability. Representativeness and comparability is qualitatively measured through an evaluation of the consistency of sample collection, handling, analyses, validation, and reporting. Sample collection through reporting will be conducted consistent with the DQO requirements outlined in the ECBSOPQAM (USEPA, 1991), USEPA CLP requirements, and USEPA data validation requirements.

3.11.2 Parameters for Level I and II DQOs For Levels I and II field measurement data, the objective for precision is to maintain factory equipment specifications to the best extent possible. For example, for the pH meter, precision will be tested by multiple readings in the medium of concern. Consecutive readings should agree within  $\pm 0.1$  standard pH units after the instrument has been field calibrated with standard buffers before each use. Likewise, water level indicator readings will be precise within  $\pm 0.01$  foot for duplicate measurements. Air monitoring instruments will be calibrated prior to field use.

As with precision, accuracy of field measurements is achieved through maintenance of equipment in accordance with factory specifications and calibration instructions. For many instruments, accuracy can be assessed through comparison of instrument response to an independent, known standard. For example, the pH meter and conductivity meters are calibrated with buffer solutions. A calibration check will be made on all water level indicators before the initiation of field work. The calibration check will be made using a surveyor's tape or other standard measuring device. If the calibration check is not within  $\pm 0.01$  foot, the instrument will be returned for service. Air monitoring instruments will be calibrated prior to shipment to the field.

Field activities performed at DQO Levels I and II are onsite measurement techniques that provide information in real time or after minimal delay. The completeness achieved for these methods may be more variable than those for standard analytical methods. A higher degree of completeness may be achieved because measurements can be readily repeated. However, at each site, conditions may constrain the use of some techniques, resulting in fewer valid analyses than anticipated.

Comparability of Level I and II data will be maintained through consistent sample collection, handling, analyses, data evaluation, record keeping, and reporting.

3.12 CORRECTIVE ACTION. Corrective or preventive actions to improve project quality will be implemented if potential or existing conditions are identified that may have an adverse impact on data quantity or quality. Corrective actions may be immediate or long term. Corrective action identification, implementation, and recording will be conducted in accordance with the ABB-ES CLEAN Quality Assurance Program Plan. Any member of the NAS Cecil Field program who identifies

a condition adversely affecting quality can initiate corrective action by completing a nonconformance report, or by issuing a memorandum to the QAM. The written communication must identify the condition and explain how it may affect data quantity or quality.

Immediate corrective action is applied to spontaneous, nonrecurring problems, such as instrument malfunctions. Staff who detect or suspect nonconformance to previously established criteria or protocol in equipment, instruments, data, or methods should immediately notify his or her Project Manager. If the problem is limited in scope, the Project Manager decides on the corrective action measure, documents the solution, and notifies the Program Manager and the QAM in a memorandum. If the problem has impaired the quality of the project or could re-occur in the future, the Project Manager will follow procedures outlined in the ABB-ES CLEAN Quality Assurance Program Plan and a corrective action form will be placed within the project files.

Corrective actions may also be initiated as a result of performance evaluations, system audits, laboratory and field comparison studies, QA project audits conducted by the QAM or Navy CLEAN QA specialists, or other activities. The QAM is responsible for documenting notifications, recommendations, and final decisions. The Project Manager is jointly responsible for notifying program staff and implementing the agreed-upon course of action. The QAM is responsible for verifying the efficiency of the implemented actions. To the extent possible, the development and implementation of preventive and corrective actions should be timed to not adversely impact project schedules or subsequent data generation and processing activities. The QAM will also be responsible for developing and implementing routine program controls to minimize the need for corrective actions.

**3.13 QUALITY ASSURANCE REPORTS.** Management personnel at all levels will receive QA reports appropriate to their level of responsibility. The QAM will receive copies of all QA documentation. QC documentation will be maintained in the project files. For the NAS Cecil Field program, verbal reports will be presented in each Project Managers' meeting.

Other types of QA reports may include periodic assessment of measurement data accuracy, precision, and completeness; results of performance audits and/or systems audits; significant QA problems and recommended solutions for future projects; and status of solutions to any problems previously identified. Additionally, incidents requiring corrective action will be fully documented. These reports will be provided to the QAM and, in turn, will be submitted to management. The summary of findings will be factual, concise, and complete. Supporting information will be appended to the report.

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**APPENDIX A**  
**DATA SHEETS AND LOGS**

# DRILLING LOG

FILE NO.

PANY NAME

## 2. DRILLING SUBCONTRACTOR

SHEET  
OF SHEETS

## 3. PROJECT

#### 4. LOCATION

**6. NAME OF DRILLER**

4. MANUFACTURER'S DESIGNATION OF DRILL

## 7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT

### WELL LOCATION

### D. SURFACE ELEVATION

10. DATE STARTED

11. DATE COMPLETED

## 12. OVERBUDEN THICKNESS

18. DEPTH GROUNDWATER ENCOUNTERED

13. DEPTH DRAILED INTO ROCK

10. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED

14. TOTAL DEPTH OF HOLE

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

## 10. GEOTECHNICAL SAMPLES

**DISTURBED**

**UNDISTURBED**

19. TOTAL NUMBER OF CORE BOXES

## 20. SAMPLES FOR CHEMICAL ANALYSIS

**VOC**

## METALS

OTHER (SPECIFY) \_\_\_\_\_

OTHER (SPECIFY) \_\_\_\_\_

OTHER (SPECIFY)

**21. TOTAL CORE RECOVERY**

5

## 22. DISPOSITION OF HOLE

## BACKLID

### MONITORING WELL

OTHER (SPECIFY) \_\_\_\_\_

**21. SIGNATURE OF INSPECTOR**

LEV

DEPTH  
B

### DESCRIPTION OF MATERIALS

**FIELD SCREENING  
RESULTS**

GEOTECH SAMPLE  
OR CORE BOX NO.  
E

ANAYTICAL  
SAMPLE NO.  
F

**BLOW  
COUNTS  
G**

REMARKS  
H

**PROJECT**

<u>TABLE NO.</u>

# DRILLING LOG

FILE NO.

**PROJECT**

~~INSPECTOR~~

**DIRECT**  
**OF THE**

REV.

007 14  
9

### DESCRIPTION OF MATERIALS

FIELD SCREENING  
RESULTS  
D

DETECT SAMPLE  
ON CORE BOX NO.  
6

ANALYTICAL  
SAMPLE NO.  
F

**BLOW  
COUNTS**

REMARKS  
H

**PROJECT**

~~FOUO~~

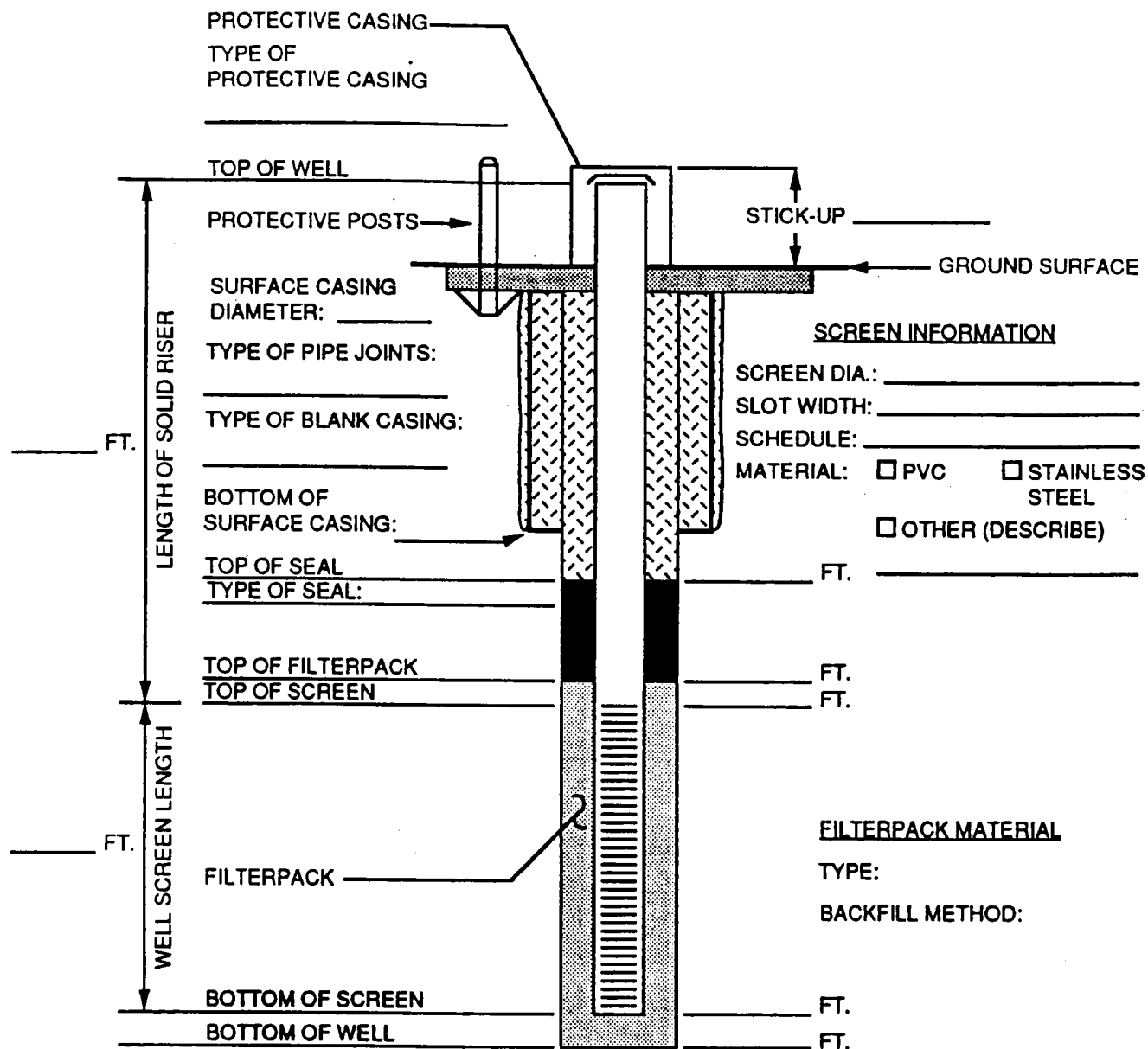
<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; width: 20%; height: 40px;"></div> <div style="text-align: center; flex-grow: 1;"> <h1 style="margin: 0;">SOIL SAMPLE SCREENING LOG</h1> </div> <div style="border: 1px solid black; padding: 2px 5px;">             PAGE __ OF __           </div> </div>	
--	--

[illegible]



ELEVATION GROUNDWATER			PROJECT
DATE INSTALLED	STARTED	COMPLETED	LOCATION (Coordinates or Station)
ELEVATION TOP OF HOLE			SIGNATURE OF INSPECTOR
TOTAL DEPTH OF HOLE			HOLE NO. (As shown on drawing title and file number)

## DOUBLE-CASED MONITORING WELL CONSTRUCTION DIAGRAM



### WELL DEVELOPMENT

METHOD: \_\_\_\_\_  
TIME SPENT DEVELOPMENT: \_\_\_\_\_  
VOLUME OF WATER REMOVED: \_\_\_\_\_  
VOLUME OF WATER ADDED: \_\_\_\_\_  
DESCRIPTION OF PREDEVELOPMENT WATER: \_\_\_\_\_  
DESCRIPTION OF POST DEVELOPMENT WATER: \_\_\_\_\_

### WATER LEVEL SUMMARY

#### WATER LEVEL MEASUREMENTS

DATE/TIME/LEVEL \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

DEPTH FROM TOP CASING AFTER DEVELOPMENT: \_\_\_\_\_

## MONITORING WELL DEVELOPMENT DATA

WELL: \_\_\_\_\_ TIME BEGAN: \_\_\_\_\_ SITE NAME: \_\_\_\_\_  
 DATE: \_\_\_\_\_ TIME ENDED: \_\_\_\_\_ PROJECT: \_\_\_\_\_  
 STATIC WATER LEVEL (ft) \_\_\_\_\_ NUMBER OF DRUMS: \_\_\_\_\_ PROJECT NUMBER: \_\_\_\_\_  
 WELL DESIGN DEPTH (ft) \_\_\_\_\_ DRUM DESIGNATIONS: \_\_\_\_\_ FIELD PERSONNEL: \_\_\_\_\_  
 WELL VOLUME (ft<sup>3</sup>) \_\_\_\_\_ SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

[illegible]

## PAGE\_\_OF\_\_

STATIC WATER LEVEL (FT) \_\_\_\_\_ AMT ONE WELL VOL (GAL) \_\_\_\_\_ PURGING SYSTEM \_\_\_\_\_  
STANDING WATER COLUMN (FT) \_\_\_\_\_ TOTAL GAL TO BE PURGED \_\_\_\_\_ SAMPLING SYSTEM \_\_\_\_\_

[illegible]

NOTES:

TURBIDITY:

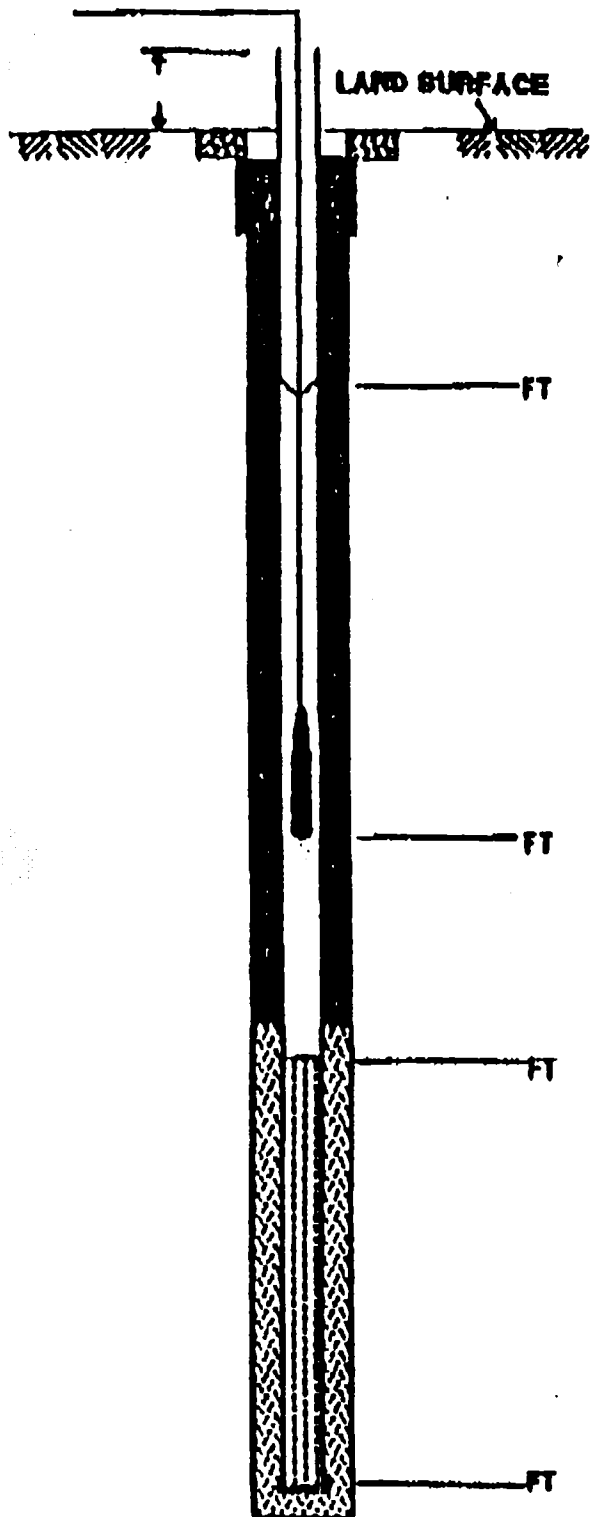
\_\_\_\_\_

ITEM DESCRIPTION \_\_\_\_\_

COST/UNIT \_\_\_\_\_

[illegible]

# AQUIFER PERFORMANCE TEST TRANSDUCER CALIBRATION LOG



PROJECT \_\_\_\_\_  
 PROJECT NUMBER \_\_\_\_\_  
 WELL NO. \_\_\_\_\_ PUMPING WELL \_\_\_\_\_

DATE \_\_\_\_\_ TIME \_\_\_\_\_

DATA LOGGER  
 SERIAL NO. \_\_\_\_\_

TRANSDUCER  
 SERIAL NO. \_\_\_\_\_

TRANSDUCER  
 RANGE \_\_\_\_\_

CHANNEL NO. \_\_\_\_\_

TEST DURATION \_\_\_\_\_

TIME OF INSTALLATION \_\_\_\_\_

STATIC DEPTH TO WATER \_\_\_\_\_ FT. \_\_\_\_\_ PSI

DEPTH OF TRANSDUCER \_\_\_\_\_

CALIBRATION  
 DEPTH \_\_\_\_\_ FT \_\_\_\_\_ PSI  
 DEPTH \_\_\_\_\_ FT \_\_\_\_\_ PSI  
 DEPTH \_\_\_\_\_ FT \_\_\_\_\_ PSI

CLOCKS SYNCHRONIZED? \_\_\_\_\_

STATIC DEPTH TO WATER \_\_\_\_\_

TIME PUMPING STARTS \_\_\_\_\_  
 \_\_\_\_\_ VERIFICATION OF DATA ACQUISITION (HR)  
 \_\_\_\_\_ VERIFICATION OF DATA ACQUISITION (HR)  
 \_\_\_\_\_ VERIFICATION OF DATA ACQUISITION (HR)

MAXIMUM PUMPING DEPTH TO WATER \_\_\_\_\_ FT \_\_\_\_\_ PSI

TIME PUMPING STOPS \_\_\_\_\_

MAXIMUM RECOVERY DEPTH TO WATER \_\_\_\_\_ FT \_\_\_\_\_ PSI

END RECOVERY \_\_\_\_\_

RECALIBRATION OF TRANSDUCER

DEPTH \_\_\_\_\_ FT \_\_\_\_\_ PSI  
 DEPTH \_\_\_\_\_ FT \_\_\_\_\_ PSI  
 DEPTH \_\_\_\_\_ FT \_\_\_\_\_ PSI

11.6 TAILGATE SAFETY MEETING REPORT.

Date: \_\_\_\_\_ Time: \_\_\_\_\_ Job Number: 07537.03

Client: U.S. Navy CLEAN

Site Location: NAS Cecil Field  
Jacksonville, Florida

Scope of Work: \_\_\_\_\_  
\_\_\_\_\_

**SAFETY TOPICS PRESENTED**

Protect Clothing/Equipment: \_\_\_\_\_  
\_\_\_\_\_

Chemical Hazards: \_\_\_\_\_  
\_\_\_\_\_

Physical Hazards: \_\_\_\_\_  
\_\_\_\_\_

Special Equipment: \_\_\_\_\_  
\_\_\_\_\_

Other: \_\_\_\_\_  
\_\_\_\_\_

Emergency Procedures: \_\_\_\_\_  
\_\_\_\_\_

Hospital: St. Vincents Phone: (904) 387-7395 Ambulance Phone: Same

Hospital Address and Route: Travel 12.5 miles northeast from the base on Highway 228 to Barrs Road, turn right, travel 0.05 mile; the hospital will be on the right side of the road.

**ATTENDEES**

Name Printed

Signature

_____	_____
_____	_____
_____	_____
_____	_____

Meeting Conducted By: \_\_\_\_\_  
Name Printed Signature

Project Safety Officer: \_\_\_\_\_ Task Order Manager: \_\_\_\_\_

## ABB ENVIRONMENTAL SERVICES, INC. ACCIDENT REPORT

**SITE INFORMATION:**

Site: \_\_\_\_\_ Job Number: \_\_\_\_\_

Location: \_\_\_\_\_

Location of Accident (if different from above): \_\_\_\_\_

Did injury involve ABB-ES employee? \_\_\_\_\_ Subcontractor? \_\_\_\_\_ Other? \_\_\_\_\_

**PERSONAL INFORMATION:**

Name of Injured Person: \_\_\_\_\_

Address of Injured Person: \_\_\_\_\_

SSN: \_\_\_\_\_ DOB: \_\_\_\_\_ Marital Status: \_\_\_\_\_

Department: \_\_\_\_\_ Date of Hire: \_\_\_\_\_

**ACCIDENT INFORMATION:**

Date of Accident: \_\_\_\_\_ Time of Accident: \_\_\_\_\_ Weather Conditions: \_\_\_\_\_

Name of Witness: \_\_\_\_\_ Telephone No.: \_\_\_\_\_

Address: \_\_\_\_\_

Accident Category: ☐ Chemical Exposure ☐ Physical Injury ☐ Motor Vehicle ☐ Fire  
☐ Property Damage (list): \_\_\_\_\_ ☐ Other: \_\_\_\_\_

Severity: ☐ Medical Treatment ☐ Non-disabling ☐ Disabling ☐ Fatality  
☐ Estimated Amount of Property Damage: \_\_\_\_\_

Classification of Injury: ☐ Heat Burns ☐ Allergic Reaction ☐ Lacerations ☐ Fracture  
☐ Chemical Burns ☐ Bites ☐ Punctures ☐ Dislocations  
☐ Radiation Burns ☐ Poison Ivy ☐ Abrasions ☐ Nausea  
☐ Toxic-Respiratory ☐ Heat Stroke ☐ Sprains ☐ Headache  
☐ Toxic-Dermal ☐ Cold Exposure ☐ Bruises ☐ Faint/Dizzy  
☐ Toxic-Ingestion ☐ Blisters ☐ Concussion  
☐ Other: \_\_\_\_\_

If chemical exposure, list all possible contaminants of concern: \_\_\_\_\_

Part(s) of Body Affected: \_\_\_\_\_ Degree of Disability: \_\_\_\_\_

Date Medical Care Received: \_\_\_\_\_ Emergency Service: \_\_\_\_\_ Follow-up Examination Needed: \_\_\_\_\_

Name and Address of Medical Facility: \_\_\_\_\_

Name of Attending Physician: \_\_\_\_\_ Telephone Number: \_\_\_\_\_

Date/Time Employee Went Back to Work: \_\_\_\_\_ Employee on Restricted Duty? \_\_\_\_\_

Estimated Number of Days Away from Work: \_\_\_\_\_

---

**CAUSE OF INJURY/ACCIDENT:**

Causative agent(s) most directly related to accident (e.g., object, substance, material, machinery, equipment, or weather): \_\_\_\_\_

Were there unsafe mechanical/physical/environmental condition(s) at the time of the accident? \_\_\_\_\_

Did an unsafe act contribute to the accident? \_\_\_\_\_ If yes, specify: \_\_\_\_\_

Did personal factors contribute to the accident (e.g., improper attitude, lack of knowledge or skill, slow reaction, fatigue, inattention, or horseplay)? \_\_\_\_\_

---

**ACCIDENT PREVENTION:**

Level of personal protective equipment required in the HASP: \_\_\_\_\_

Was injured using required equipment? \_\_\_\_\_ If not, how did actual equipment differ from what was required in the HASP? Describe: \_\_\_\_\_

Was personal protective equipment required in the HASP adequate for site conditions? \_\_\_\_\_

If no, what additional equipment was needed? \_\_\_\_\_

What can be done to prevent a reoccurrence of this type of accident (e.g., ventilation, machine modification/guarding, modification of work practices, or additional training)? \_\_\_\_\_

---

**NARRATIVE:**

Provide a detailed description of how and why the accident occurred. Include objects, equipment, tools, circumstances of assigned duties, weather, etc. (be specific): \_\_\_\_\_

Signature of Preparer: \_\_\_\_\_ Date: \_\_\_\_\_

Signature of Site Manager: \_\_\_\_\_ Date: \_\_\_\_\_

**SEND A COPY OF THE COMPLETED FORM TO THE MANAGER, HEALTH AND SAFETY, PORTLAND, ME.**

## **APPENDIX B**

### **FIELD EQUIPMENT, OPERATION, MAINTENANCE, AND CALIBRATION**

## SECTION 2.0 FOXBORO ORGANIC VAPOR ANALYZER 128

The following section outlines procedures for field operations with the Foxboro OVA Model 128.

### 2.1 Instrument Profile

<b>Hazard Monitored:</b>	Toxic concentrations of organic vapors
<b>Application:</b>	To determine relative concentrations of air contaminants. The information is used to establish levels of protection and other control measures such as site specific action levels. When equipped with the gas chromatographic option it can be used for limited qualitative and quantitative assessment of samples.
<b>Components:</b>	A survey probe with a meter read out; self contained hydrogen cylinder for the detector; low and high audible alarm; range selector; lead-acid gel battery; gas select control; pressure gauges.
<b>Detection Method:</b>	Flame ionization.
<b>Operation:</b>	The sample is drawn by a pump to the detector where it is ionized (combusted). The electrons released are collected at an electrode which generates a current. The greater the current, the higher the concentration. The instrument will detect only organic compounds.
<b>Read Out:</b>	The meter can be read on the following ranges: 0-10, 0-100, or 0-1000 ppm methane equivalent.
<b>Calibration:</b>	The instrument is factory calibrated to methane. The calibration should be checked before each use with a calibration check gas.
<b>Inherent Safety:</b>	The OVA is approved for Class I Division 1 Groups ABCD.
<b>Limitations:</b>	The instrument used in the survey mode in unknown atmospheres is strictly quantitative with the reading equivalent to methane. Because the instrument is extremely sensitive to methane, it has a limited application in areas where toxic vapors and gases are found with methane because methane masks the other compounds. The limit of use is about eight hours due to both the hydrogen supply and battery life. It requires very high grade hydrogen (Prepurified or Zero grade, less than 0.5 ppm total hydrocarbons as methane). It requires more training than other instruments, especially when used in the chromatographic mode.
<b>EPA Action Guides:</b>	None established. It depends on the toxicity of the specific compound being monitored.

## 2.2 Field Procedures

The following sections detail the procedures that are to be followed when using the OVA in the field.

<i>Procedure</i>	<i>Section</i>	<i>Frequency</i>
Start-up Procedure	2.2.1	Prior to each use of the instrument
Operational Check	2.2.2	Prior to each use of the instrument
Pumping System Check	2.2.3	Prior to each use of the instrument
Shut Down Procedure	2.2.4	After each use of the instrument
Battery Charging	2.2.5	After each use
Field Calibration Check	2.2.6	Prior to each use of the instrument
Hydrogen Refilling	2.2.7	As Needed
Clean Particle Filters	2.2.8	Daily under dusty conditions; weekly under good conditions
Routine Service	2.3.1	Monthly

### 2.2.1 Start Up Procedure (Survey Mode)\*

- a. Attach the probe to the main instrument package. Be careful to properly line-up the electronic jack and the sample line. Check the battery condition by moving the instrument switch to the battery position. The needle should deflect past the white line on the probe. If it does not, do not use the instrument. Place the unit on charge. A deflection of the meter beyond the white line indicates that the battery has more than four hours of operation at 22 degrees C before it is necessary to recharge it. (Lower temperatures will shorten the operating time.)
- b. Move the instrument switch to on and allow a five minute warm-up.
- c. Move the pump switch to the on position and then place the instrument panel in the vertical position and check the sample flow rate. The flow should be 1.5 to 2.5 liters per minute at 760 mm of pressure and 22 degrees C.
- d. Set the calibrate switch to X10 position and use the calibrate knob and set the meter to read 0. Use the calibrate knob to set the level the warning alarm. Turn the volume knob fully clockwise.
- e. Open the hydrogen tank valve and the hydrogen supply valve one or two turns. The hydrogen supply value gauge should read between 8 and 12 psi. (For eight hours of operation, the hydrogen tank pressure should be at least 1500 psi). About 150 psi of hydrogen is required per each hour of survey operation. (If the GC option is used, the amount of hydrogen used will increase.)

- f. After approximately one minute, depress the igniter button. A barely audible popping sound will be heard when the detector lights and a sudden sharp positive deflection of the meter on the probe will be observed. **Do not depress the igniter button for more than five seconds.** If the detector does not light, (indicated by a slowly rising positive deflection of the meter) wait for one minute before attempting to light the detector.
- g. After the detector is lit, use the calibrate knob to zero out the ambient background. For maximum sensitivity below 10 ppm, set the calibrate switch to X1 and readjust the zero on the meter. To avoid a false flame-out alarm indication, set the meter to 1 ppm with the calibrate knob and make differential readings from there.
- h. When using the OVA in the survey mode, make certain that the sample inject valve remains in the full out (up) position and that the backflush valve is either full in (down) or full out (up).

\* For a description of the *Survey Mode*, refer to section 2.4.1.

**2.2.2 Operational Check**

- a. Follow the start-up procedure in 2.2.1.
- b. With the range switch set on the X-10 position, hold the tip of a solvent-based magic marker at the probe opening. If the meter deflects upscale, the detector is lit and the instrument is working properly. If the instrument will not start-up or check-out properly, notify the CDM Regional Field Equipment Manager to obtain a replacement.

**2.2.3 Pumping System Check**

- a. Follow the start-up procedure and operational check.
- b. Block the intake of the probe. The pump should stall. If it does not stall, check the seals at the probe and the connection of the probe to the main instrument case. If the pump still does not stall, notify the CDM Regional Field Equipment Manager to obtain a replacement.

**2.2.4 Shut Down Procedure**

- a. Close the hydrogen supply valve and the hydrogen tank valve. Do not over-tighten these valves. As soon as the valves stop turning, they are closed. They are easily damaged by overtightening.
- b. Move the instrument switch to off.
- c. Wait 5 seconds and then move pump switch to off. The instrument is now in a shut down configuration.
- d. If possible, immediately place the instrument on charge.

**2.2.5 Battery Charging**

- a. In a non-hazardous environment, plug the charger connector into mating connector on the battery cover and insert the ac plug into a standard 115 v ac wall outlet.
- b. Move the battery charger switch to the ON position. The light above the switch should light.
- c. The battery charging is indicated by the meter on the charger fully deflected to the left. A fully charged battery is indicated when the meter pointer is in line with the *charged* marker above the scale.
- d. Approximately one hour of charging is required for every hour of operation. Overnight charging is recommended after each use. The batteries are of a type which cannot be damaged if left on the charger for a long period of time.
- e. When the charging is complete, turn the battery charger switch to OFF and disconnect the charger from the battery assembly.

### 2.2.6 Calibration Check

- a. Follow the start-up and operational check procedures.
- b. Flush a gas bag (tedlar recommended) three to four times with a known methane standard near 100 ppm (i.e. Foxboro HGC-225 methane in air or equivalent). Fill the bag with about two liters of the gas.
- c. Put the OVA on the X-10 scale and zero.
- d. Using clean tygon tubing, feed the standard into the instrument. After fifteen seconds adjust the gas select dial until the reading on the meter is the same as the value of the gas standard. If the instrument will not calibrate, notify the CDM Regional Field Equipment Manager and obtain a replacement.
- e. Record in the field log the instrument ID No.; the initial and final gas select dial settings; the date and time; the concentration of the calibration gas; and the name of the person who calibrated the instrument.

### 2.2.7 Hydrogen Refilling

- a. In a well ventilated area, away from any source of flame or spark, attach the hydrogen filling hose securely to a cylinder of zero grade hydrogen (less than 0.5 ppm total hydrocarbons as methane).
- b. Attach the filling hose to the instrument fill connection.
- c. Check to ensure that all of the valves on the instrument are closed and open the supply valve on the hydrogen cylinder.
- d. Turn the fill/bleed valve slowly to bleed and purge the hose for ten to fifteen seconds.
- e. Turn the fill/bleed valve to the close position. Open the refill valve on the instrument slightly, open the hydrogen tank valve on the instrument panel, and turn the fill/bleed valve to fill.
- f. After the hydrogen tank is filled, close all the valves. Bleed the filling hose and disconnect it from the instrument. Then disconnect the hose from the hydrogen cylinder. (A small amount of hydrogen at high pressure will be present in the hydrogen supply system.)
- g. As a leak check, with the instrument shut down, observe the hydrogen tank pressure gauge. A decrease of more than 350 psi/hour indicates a significant leak in the hydrogen supply system.

### 2.2.8 Particle Filter Cleaning

Under dusty conditions and repeated use, the particle filters in the OVA will require cleaning. They are cleaned in the following manner.

- A filter is located behind the sample inlet connector on the Side Pack Assembly. It is removed for cleaning by using a 7/16 inch thin wall socket to unscrew the Fitting Assembly. The filter cup, "O" ring and loading spring will then come out. The porous stainless filter cup can be cleaned by blowing out with air. Reassemble in reverse order ensuring that the "O" ring seal on the Fitting Assembly is intact.
- A particle filter is located in each pick-up fixture. One of these filters must be in the sample line whenever the instrument is in use. Sampling fixtures should be cleaned by blowing out with air to remove particles of dirt.

An SCBA cylinder can be used to supply air for cleaning. However, in very dusty situations, other air may be required.

### 2.2.9 Operation

- a. Follow the start up, operational check, and calibration check procedures.
- b. Set the range switch to the appropriate range. If the concentration of gases or vapors is unknown, set the function switch to the 0 - 10 ppm range and adjust it if necessary.
- c. While taking care not to permit the OVA to be exposed to excessive moisture, dirt, or other contamination, monitor the work activity as specified in the CDM Site Health and Safety Plan.
- d. When the activity is completed or at the end of the day, carefully clean the outside of the OVA with a damp (not dripping wet) disposable towel to remove any visible dirt. Return the OVA to a secure area, shut it off (2.2.4), and place the unit on charge.
- e. With the exception of the probe inlet and the exhaust, the OVA may be wrapped in clear plastic to prevent it from becoming contaminated and to prevent moisture from getting inside in the event of precipitation.

## 2.3 Servicing Procedures

The following sections cover those activities which are to be done by the CDM Regional/Subsidiary Field Equipment Manager or a trained designee only. They are not intended for use by CDM field personnel and should not be attempted by CDM field personnel under any circumstances.

The a calibration/maintenance form is to be filled in completely and a new calibration sticker attached whenever an OVA receives servicing. This is true of both CDM and rental instruments.

### 2.3.1 Routine Service

The OVA's performance is affected by a number of factors. These include but are not limited to the clogging of the dust filters, formation of deposits on in the detector assembly, leaks in the air and hydrogen lines, and the drift of the calibration. Because of these factors, OVA's are not to be left out for more than one month before receiving routine servicing or being replaced with a fresh instrument. If a site is going to be inactive for more than one week, all monitoring instruments are to be returned to the Regional Warehouse/Staging Area for servicing and/or reassignment.

Maintenance personnel should be thoroughly familiar with instrument operation before performing maintenance. It is essential that all matters relating to safety, operation, servicing and maintenance, be thoroughly understood. There should be no potential igniters or flame in the area when filling, emptying or purging the hydrogen system and the instrument should be turned off.

Extreme care should be exercised to ensure that required parts replacement is accomplished with the parts specified by Foxboro. Modifications to an OVA are not permitted. Any modifications, substitution of parts not specified by Foxboro, or any incorrect repair will invalidate the Inherent Safety rating. Disassemble the instrument only in a non-hazardous atmosphere.

<i>Procedure</i>	<i>Section</i>	<i>Frequency</i>
Check Pumping System	2.2.3	Prior to use
Check Calibration	2.2.5	Prior to use and at instrument return
Calibration	2.3.2	Monthly and after servicing
Check Particle Filters	2.3.4	Weekly
Clean Burner Chamber	2.3.6	Weekly
Change Charcoal	2.3.7	As needed
Purge Hydrogen System	2.3.8	As needed

### 2.3.2 Calibration

- Carefully remove the instrument from its case.
- Turn on the electronics and zero the OVA on the X-10 scale. Set the gas select dial to 300.
- Turn on the pump and open the hydrogen valves. Ignite the detector. Go to the survey mode.
- Introduce a National Bureau of Standards (NBS) traceable methane standard near 100 ppm into the OVA. This can be done from a gas bag (tedlar recommended) or a cylinder of gas. If a cylinder of compressed gas is used, use a T connector to supply gas to both the OVA and a rotometer. With the OVA pump on, adjust the gas flow to so that the rotometer shows a slight excess of flow. Adjust R-32 trimpot on circuit board to make meter read to value of the standard.
- Turn off the hydrogen and adjust meter to 40 ppm. Switch to X1 scale and adjust R-31 trimpot to make meter read 4 ppm. Return to X10 scale and adjust meter needle to 40 ppm. Switch to X100 scale and adjust R-33 trimpot to make meter read 400 ppm.
- Fill in the calibration/maintenance log (Exhibit B) and place a new calibration sticker on the instrument.

### 2.3.3 Calibration To A Gas Other Than Methane

The OVA may be calibrated to any certified hydrocarbon calibration gas. This is to be done only at the direction of the CDM Regional/Subsidiary Health and Safety Manager. After calibration, all subsequent instrument readings must be expressed as ppm in the gas used (i.e. 20 ppm benzene equivalent). To calibrate to another gas, use the following

# CALIBRATION/MAINTENANCE FORM FOR OVA 128

Date: \_\_\_\_\_ Time: \_\_\_\_\_  
 Name: \_\_\_\_\_ Region: \_\_\_\_\_ Site: \_\_\_\_\_  
 EPA Tag no.: \_\_\_\_\_ Rental: ☐ yes ☐ no Rental Source: \_\_\_\_\_ Serial no.: \_\_\_\_\_  
 Last used at region: \_\_\_\_\_ Site: \_\_\_\_\_  
 Last Calibrated by: \_\_\_\_\_ Region: \_\_\_\_\_ Date: \_\_\_\_\_

## CONDITION OF UNIT

Was unit STORED/SHIPPED with slight amount of H<sub>2</sub> in tank ☐ yes ☐ no  
 Were any PARTS/ACCESSORIES missing or damaged ☐ yes ☐ no  
 if YES, list & describe: \_\_\_\_\_

Were any of the three VALVES OVERTIGHTENED or left OPEN ☐ yes ☐ no  
 Was unit returned Clean and in WORKING order ☐ yes ☐ no  
 if NO, describe condition: \_\_\_\_\_

## FUNCTION TEST

- |   |  |
|---|--|
| 1. Battery test on/above line _____         | 2. Pump flow rate _____ PPM                            |
| 3. Flame out audio at speaker _____         | 3. H <sub>2</sub> low valve pres. _____                |
| 5. PPM alarm audio at speaker _____         | 6. QUAD RINGS checked _____                            |
| 7. SAMPLE INJECT valve operates _____       | 8. Backflush valve operates _____                      |
| 9. Check for AIR/H <sub>2</sub> leaks _____ | 10. IGNITION response time _____<br>(less than 2 sec.) |

## CALIBRATION

Methane + air std. \_\_\_\_\_ PPM Alternate calibration Gas \_\_\_\_\_  
 Gas select (SPAN) setting ☐ 3.0 PPM \_\_\_\_\_

### [WARNING - R38 factory adjustment only]

Background reading \_\_\_\_\_ PPM {0-6 PPM acceptable tolerance}  
 X100 CH<sub>4</sub> test (before adj. R32) \_\_\_\_\_ PPM after \_\_\_\_\_ PPM  
 X10 flame/pump off (before adj. R31) \_\_\_\_\_ PPM after \_\_\_\_\_ PPM  
 X1000 flame/pump off before adj. R33) \_\_\_\_\_ PPM after \_\_\_\_\_ PPM

## CALIBRATION CHECK

Methane standard \_\_\_\_\_ PPM Alternate Calibration Gas \_\_\_\_\_  
 Initial gas select \_\_\_\_\_ PPM \_\_\_\_\_  
 Final gas select \_\_\_\_\_  
 Calibration satisfactory: ☐ yes ☐ no

Signature: \_\_\_\_\_ Title: \_\_\_\_\_

procedure.

- a. Follow the calibration procedure 2.3.2.
- b. Fill and flush three or four times a gas bag (tedlar recommended) with the certified NBS traceable calibration gas. Fill the bag with two to three liters of the gas. If the gas is toxic, this must be done in a fume hood.
- c. Set the OVA scale to the setting for the concentration of the gas and feed the gas into the probe through clean tygon tubing. After fifteen seconds, adjust the gas select switch to adjust the meter reading to the value of the gas.
- d. Record the calibration results on a calibration/maintenance log sheet (Exhibit B) and attach a new calibration sticker to the OVA. Make certain that the instrument is clearly marked as to the gas for which it is calibrated.

### 2.3.4 Particle Filters

The particle filters in the OVA are cleaned in the following manner.

#### *Primary Filter*

This filter is located behind the sample inlet connector on the Side Pack Assembly. It is removed for cleaning by using a 7/16 in thin wall socket to unscrew the Fitting Assembly. The filter cup, "O" ring and loading spring will then come out. The porous stainless filter cup can be cleaned by blowing out or washing in solvent. If a solvent is used, care should be taken to ensure that all solvent is removed by blowing out or heating the filter. Reassemble in reverse order ensuring that the "O" ring seal on the Fitting Assembly is intact.

#### *Secondary Filter*

A particle filter is located in each pick-up fixture. One of these filters must be in the sample line whenever the instrument is in use. Sampling fixtures should be periodically cleaned with an air hose and/or detergent water to eliminate foreign particle matter. If a solvent is used, the fixture should be subsequently cleaned with detergent and baked out at 120 degrees F to eliminate residual hydrocarbons.

#### *Mixer/Burner Assembly Filter*

A porous metal particle filter is incorporated in the Mixer/ Burner Assembly which screws into the Preamp Assembly. This filter is used as the sample mixer and inlet flame arrestor in the chamber. The filter should not become contaminated under normal conditions but can be cleaned or the assembly replaced if necessary.

Access to this filter or output surface does not require removing the instrument from the case. For access, remove the safety cover using a hex key wrench (supplied) then unscrew the exhaust port. The Filter Assembly can now be seen on the side of the chamber (Preamp Assembly) and can be cleaned with a small wire brush.

#### *Exhaust Flame Arrestor*

A porous metal flame arrestor is located in the exhaust port of the detector chamber (Preamp Assembly). It acts as a particle filter on the chamber output and restricts foreign matter from entering the chamber. This filter may be cleaned by removing the exhaust port. For access, see Mixer/Burner section above. Note that the filter is captive to the exhaust port. Clean the filter with a solvent or detergent and ensure that it is dry and completely baked out at 120 degrees F before reinstalling.

### 2.3.5 Hydrogen Tank Supply & Refill Valves

After some time, the Teflon washers under each valve packing nut can "cold flow" (move with pressure) and allow hydrogen to leak. Leakage can be determined by using Leak-Tec, Snoop or a soap solution around the valve stems. This leakage can usually be stopped by tightening the compression nut (adapter) as outlined below.

- a) Unscrew the packing nut with a 7/16 inch wrench.
- b) Unscrew the valve.
- c) Replace the compression rings.

This compression is against soft material and only a small amount of force is necessary to sufficiently compress the Teflon washers. If, after tightening, leakage still occurs, it would be advisable to replace the two Teflon washers, as follows:

- a) Drain hydrogen system slowly and to the extent necessary to work on the leaking valve(s). Observe appropriate safety precautions. There should be no potential igniters in the area.
- b) Remove all three (3) knob screws and knobs.
- c) Remove the compression nut on the valve that is not sealing properly. Remove the stem by unscrewing it from the valve body. Observe the sandwich of metal and Teflon washers and note their order.
- d) Visually check the Kel-FTM seat on the stem for cracks or foreign material. Wipe clean, if necessary, with a lint free cloth (no solvents or oils) and replace if damaged.
- e) Remove the washers and replace the Teflon washers (the factory process is a light wipe of hydrocarbon free silicone grease).
- f) Replace the stem assembly in the valve body and tighten lightly.
- g) Push the washers down into the compression area in the same order as noted upon removal. Replace the compression nut and tighten snugly.
- h) Close the low pressure valve and fill the tank assembly. Check valves for leaks. Tighten again, if necessary, and reassemble the unit.

### 2.3.6 Burner Chamber Cleaning

- a. Remove the safety cover and the exhaust port of the detector chamber (on the bottom of the case) and clean the cavity and the electrode using the small wire brush supplied with the analyzer.
- b. After cleaning, replace the exhaust port and safety cover and reignite and recalibrate the OVA.
- c. Fill in the calibration/maintenance log.

### 2.3.7 Charcoal Replacement

- a. Remove the charcoal cartridge from the instrument and carefully empty the used charcoal.
- b. Refill the cartridge with fresh charcoal. Foxboro P/N CSC004 or equivalent. Fill the cartridge completely.
- c. Replace the cartridge on the OVA.
- d. Complete a calibration/maintenance log.

### 2.3.8 Purging of Hydrogen Supply Lines

Contamination in the hydrogen fuel system is usually the direct result of contaminated hydrogen gas or contamination introduced during the filling operation. Filling hose contamination can be caused by storing the hose in a contaminated area.

To remove contamination, the fuel system should be purged with hydrogen. Effective purging is accomplished as follows:

- a. Disconnect the capillary tube fitting to the manifold block which has the low pressure gauge (Hydrogen Supply Pressure Gauge and Hydrogen Supply Valve). This disconnects the capillary tubing from the hydrogen line so that hydrogen may be purged at a reasonable rate from the tank assembly through the regulators, gauges and valves. After disconnecting the capillary, fill the hydrogen tank in the normal manner.
- b. Open the tank valve and hydrogen supply valve. This will bleed the hydrogen from the tank through the hydrogen fuel system, purging contamination which is in vapor form. There is the possibility that contamination has been introduced into the hydrogen fuel system which is not readily purged by the hydrogen gas, but this is unlikely.
- c. After purging with clean hydrogen two or three times, the capillary tube should be reconnected and the background again checked. Five or ten minutes should be allowed before assessing the background reading, since contaminated hydrogen can be trapped in the capillary tube.
- d. If another clean instrument is available, the fuel system from the clean instrument can be connected to the contaminated instrument to verify whether the problem is associated with the hydrogen fuel supply system. The interconnection should be made to the capillary tube of the contaminated instrument.
- e. Recalibrate and fill in the calibration/maintenance log.

### 2.4 Air Sampling System Maintenance

A potential problem associated with the OVA instrument is that leaks can develop in the air sample pumping system. These leaks can result in dilution or loss of sample, causing low reading of vapor concentration and slow response.

The OVA is equipped with a flow gauge that provides a method to check for air leaks. Assemble the pickup probe selected for use to the read out assembly and then position the sidepack vertically so the flow gauge may be observed. Cover the end of the pickup probe with your finger and observe that the ball in the flow gauge goes to the bottom, indicating no air flow (if the ball has a slight chatter while on the bottom, this is acceptable). Cover the center of the chamber exhaust port with your thumb and again observe the ball going to the bottom. Another simple check is to expose the pickup probe to a light vapor (butane) and observe that the meter responds in approximately 2.0 seconds. It should be noted that slow meter response may also indicate a restriction in the air sampling system.

Failure of the ball to go to the bottom when the inlet is blocked indicates a leak in the system between the probe and the pump inlet or the inlet check valve. To isolate the problem, remove parts, one at a time, and again block off the air inlet. Remove the pickup probe(s) and cover the air inlet at the Read Out Assembly. If the ball goes to the bottom, check that the *read out to probe* seal washer is in place and replace the gaskets, holding them back against the seal while tightening the nut. Recheck, and if leakage is still present, it is probably in the probe (pickup fixture), which should be repaired or replaced.

If leakage is indicated as being past the read out handle when the connection to the sidepack is tight, disconnect the sample line at the fitting on the sidepack and cover this inlet with your finger. If the flow gauge ball goes to the bottom, the problem should be a leak in the umbilical cord/Read Out Assembly, which should be investigated and repaired. There is also the possibility of a leaking check valve in the pump which would not show up on this test. If the leakage is not found in the umbilical cord, it is most likely in the pump check valve. The pump should be replaced.

If the ball does not go to the bottom, the leak will be either in the flow gauge or its connecting tubing. Visually check that the tubing is connected and if so, the flow gauge should be repaired or replaced. Check the *O ring* installation in the sample inlet connector (Fitting Assembly).

As an alternate approach, leaks on the inlet side of the pump can be detected by using alcohol on a *Q Tip* and lightly swabbing the connection one at a time or by directing organic vapor or smoke at the potential leakage points and observing the meter response or audible alarm.

Leaks beyond the pump are easier to locate, as any of the commercially available leak detection solutions can be used. Cover the exhaust port, which will place the exhaust system under pressure, and check each connection, one at a time. Replace the Teflon tubing or retape the threaded connections with Teflon joint tape. Check the igniter/Mixer/Burner Assembly where they screw into the detector, the high voltage terminal screw on the side of the Mixer/Burner and exhaust port itself. If after these checks, the flow gauge ball still will not go to the bottom with the exhaust blocked, the problem is likely a leaking exhaust check valve in the pump, which should be repaired or replaced.

## 2.5 Gas Chromatograph (GC) Option

The OVA provides efficient and accurate indication of total organic compound concentrations on a continuous sampling basis. However, in areas where mixtures of organic vapors are present, it often becomes necessary to determine the relative concentration of the components and/or to make quantitative analysis of specific compounds.

To provide this capability, a gas chromatograph (GC) option is available. When the GC option is used, the capability of the OVA includes both qualitative and on-the-spot quantitative analysis of specific components present in the ambient environment.

This section is applicable only to an OVA with the optional gas chromatograph (GC) system. It presents maintenance and trouble shooting procedures for common problems associated with the GC mode of operation. It is not intended to give instructions in the uses of the GC option. Only trained personnel should operate the OVA in the GC mode in the field.

### 2.5.1 Modes of Operation

The OVA with GC option has two modes of operation. The first mode is the measurement of total organic vapors in the same manner as described for the basic OVA instrument. This mode is referred to as the *Survey Mode*. The OVA is in the Survey Mode of operation whenever the Sample Inject Valve is in the *out* position.

The second mode of operation is called the *GC Mode*. The OVA is in this mode of operation any time a sample has been injected into the GC system and the sample is being transported through the GC column. This section provides a brief description of how a gas chromatograph (GC) option operates. A comprehensive discussion of gas chromatography theory, column selection, and data analysis is beyond the scope of this manual.

The OVA with GC option can be utilized for many types of analysis in the outdoor or indoor ambient environment or for specific laboratory type analysis. The OVA was not designed to compete with the research or process gas chromatograph but to complement these instruments or eliminate their need in field applications. Foxboro publishes Application/Technical Notes to assist the operators in applying the instrument to field monitoring situations.

The OVA in GC mode requires the following: 1) A carrier gas to transport the sample through the column; 2) Hydrogen gas for operation of the FID; 3) A clean air supply to support combustion to the FID. In addition, a method for injecting a known volume of sample air (aliquot) to be analyzed is required. The OVA GC system uses the hydrogen fuel for the FID also as the carrier gas. The clean air supply is simply the normal air sample pumped to the FID. During the GC analysis, this air is scrubbed in a charcoal filter to provide the clean air supply.

A valving arrangement is incorporated to provide a method for transferring a fixed volume of air into the GC system for analysis. The sample air injected into the GC column is the same sample being analyzed by the OVA for total organic vapor concentration. Therefore, the instrument provides the unique capability to observe the total organic vapor concentration of the sample prior to injecting it into the GC system.

### 2.5.2 GC Columns

Columns are available in 4, 8, 12, 24, 36, and 48 inch lengths as standard offerings with any of the column packings listed below. Longer lengths are available from Foxboro in 12-inch increments on a non-standard basis.

#### Foxboro Designation

#### Material

A	20% Dioctyl Phthalate on Chromosorb-P, AW 60/80 Mesh
C	Chromosorb 101, 60/80 Mesh
D	20% Ucon 50 HB 280 on Chromosorb-P, AW 60/80 Mesh
E	20% Carbowax 400 Chromosorb-P, AW 60/80 Mesh
F	5/1.75% Diethylhexyl Sebecate/Bentone 34 on Chromosorb W, AW 60/80 Mesh

G	10% OV-101 on Chromosorb W, HP 60/80 Mesh
T	10% 1,2,3-Tris (2-cyanoethoxy) Propane on Chromosorb P, AW 60/80 Mesh
B	3% Diisodecyl Phthalate on Chromosorb W, AW 60/80 Mesh
PT	Poropak T, 60/80 Mesh
Q	Poropak Q, 60/80 Mesh
H	20% Carbowax 20M Chromosorb P, AW 60/80 Mesh
J	n-Octane on Porasil C, 80/100 Mesh
N	Poropak N, 60/80 mesh

### 2.5.3 Column Maintenance

Any column can be contaminated with compounds having long retention times. This will result in high background readings. This condition can be checked by installing a new column or a blank column (tubing only). If this reduces the background reading, the contaminated column should be baked at 100 degrees C for three to four hours in a drying oven while passing nitrogen through the column. Higher temperatures may permanently damage the column packing.

When installing any column, avoid touching the ends, as this may cause contamination. Also, ensure that the fittings are tight to avoid hydrogen leakage.

The following simple test may be run to determine whether the GC column is contaminated. While in a clean ambient air background, place the Sample Inject Valve in the In (GC Mode) position. Observe the background reading on the meter or recorder. After one to two minutes, change the position of the Backflush Valve and again observe the background reading. If the background reading went down and then started to increase in one to two minutes, the column is probably contaminated and needs to be cleaned. If hydrogen flows into one end of the column for a long period of time, the contamination is pushed into the column. Then when the hydrogen flow is reversed, the exhaust end of the column will be clean until the contamination is again pushed through. To clean a column, the purge gas must be run through the column in one direction until all contamination is removed. Contaminated columns can be avoided by backflushing the column after every analysis.

### 2.5.4 Charcoal Filter Assembly

After repeated use, the Charcoal Filter Assembly will become saturated. Periodically, the operator should check the effectiveness of the activated charcoal.

This is done by operating the unit with the Sample Injection Valve in and passing the probe near a concentrated sample of compound being analyzed. The read out should remain nearly steady should not rise more than 0 to 2 ppm. If rise is more than 2 ppm, replace the old charcoal with new activated charcoal according to the procedure in section 2.3.8. Care should be taken to completely fill the tube to prevent a path for sample to bypass the charcoal. The life of the charcoal depends on the length of time of exposure and the concentration level during that exposure. When changing charcoal, remove any fine charcoal dust from the assembly.

Another test of the charcoal filter is to note the background reading with the Sample Inject Valve out and then the reading with the valve in. The level should never be higher when the valve is in the in position and the charcoal filter is in the air line. If the reading with the valve in the in position is higher, the charcoal filter is probably contaminated and acting like a contamination emitter.

## 2.6 High Background Reading

On occasion, the background reading may be relatively high under normal ambient conditions. Ambient background reading will vary somewhat depending on the geographical location where the instrument is being used. However, the background reading normally should be in the range of 3 to 5 ppm as methane. The acceptable background reading consists of 1 to 1.5 ppm of methane which is present in the normal air environment. In addition to the measurement of a normal methane background, there will normally be 2 to 4 ppm of equivalent methane background caused by acceptable levels of contamination in the hydrogen fuel and/or hydrogen fuel handling system resulting in a total of equivalent methane reading of 3 to 5 ppm in clean air.

If the background reading goes above 5 ppm to 6 or 7 ppm, this is normally still acceptable since any measurement is additive to that background reading, i.e., 2 ppm on top of 5 or 2 ppm on top of 7 provides the same differential reading, however, the lower background is obviously desirable.

The background reading is zeroed out or nulled even though in reality the background still exists. The background reading is measured by zeroing the meter with the flame out and noting the meter indication after the flame is on.

The cause for a high background reading is usually associated with contamination in the hydrogen fuel system. This will, of course, cause a background reading since this is the function of the basic detector to measure contamination entering the detector chamber. In addition, contamination present in the hydrogen will many times leave a small unobservable deposit on the burner face which can continue to generate a background reading when the detector is in operation and the burner assembly is heated.

Another possible cause of contamination is the Mixer/Burner Assembly when the contamination is trapped in the porous bronze sample filter. This is not a common problem and usually only happens when an unusually high level of contaminant is drawn into the assembly. Another possible cause of high background reading is contamination in the air sample line to the detector. This is uncommon but can be the source of the problem.

An OVA that has the Chromatograph Option can have high background caused by saturation or contamination of the activated charcoal filter, which is in the line during chromatograph analysis, or of the column which is in the hydrogen line at all times.

Prior to analyzing the problem, the OVA should be checked for proper operation. Calibrate the instrument to methane as referenced. If, after checking that the OVA is properly calibrated, the background is still higher than normal for ambient conditions, the following procedure should be followed to isolate the cause of the problem:

- a. Let the OVA run for a period of time (15 to 30 minutes) and see if the background level decreases as a function of time. The background could go down as a result of clearing line contamination which is removable simply by the normal flow of air through the sample line.
- b. Take a reading in a known, relatively clean air environment. Normally, outside air environment is clean enough to assess by comparison whether the background reading is internal to the instrument or is present in the location where the instrument is being used.
- c. If the OVA has the Gas Chromatography Option, depress the sample inject valve, so that the activated charcoal is in the line, and observe whether the background reading goes down and stays steady after elution of the air peak. The reading should always go down or stay the same but never increase when the sample valve is depressed, since the charcoal filter will remove trace elements of organic vapors in the air sample heavier than ethane. If another activated charcoal filter is available, this may be attached to the end of the probe to scrub the air so that a clean air sample is supplied to the detector. The external activated charcoal filter can be used on any instrument, with or without chromatograph, for providing a clean air sample to assess background level.
- d. If the background cannot be reduced by any of the previous steps, remove the safety cover and the exhaust port of the detector chamber (on the bottom of the case) and clean the cavity and the electrode using the small wire brush supplied with the analyzer (2.3.7). This will remove any small quantities of contamination which could be the source of the background vapor. After cleaning, replace the exhaust port and safety cover and reignite the OVA. If detector contamination was the cause, the problem should be immediately resolved and the ambient background will drop to an acceptable level.
- e. If the high background is still present, the various parts of the sample flow line such as pickup probes, umbilical cord to the instrument, etc., should be investigated by the process of elimination to see if the contamination can be isolated.
- f. Serious contamination in the air sample line is very uncommon. However, if very large doses of low vapor pressure compounds are sampled, there is a possibility of residual contamination. This would eventually clear itself out but may take a considerable period of time. A typical cause for high background from the sample line is a contaminated Mixer/Burner Assembly. If heavy contamination of the Mixer/Burner is indicated, replace the Mixer/Burner Assembly.
- g. In the event of contamination in the pump or other internal parts of the sample flow lines which cannot be removed, the sample flow components have to be disassembled and cleaned. This is normally a factory operation, however, components such as the pump can be replaced in the field along with any contaminated tubing.
- h. High background readings on OVAs which include the Gas Chromatograph Option can be caused by other sources of contamination. If the charcoal filter mounted on the instrument panel is saturated, contaminated air would be supplied to the detector and raise the ambient level background. To check for this, refill the cartridge with fresh charcoal, Foxboro P/N CSC004

or equivalent. This would determine if the charcoal was the source of the background reading. It is also possible that a high background reading could be due to contamination in the column. This could be caused by compounds slowly eluting from a column which has become contaminated. The easiest way to check for column contamination is to replace the column with a clean column or a short empty piece of column tubing and see if the high background reading drops.

- i. If the above steps do not correct the high background, the cause will normally be contamination in the hydrogen fuel system.

Contamination in the hydrogen fuel system is usually the direct result of contaminated hydrogen gas or contamination introduced during the filling operation. Filling hose contamination can be caused by storing the hose in a contaminated area.

To remove contamination, follow the procedure in 2.3.8.

## 2.7 Troubleshooting

The a summary of field troubleshooting procedures is presented below. If necessary, the instrument can be easily removed from the case by unlocking the four (4) 1/4 turn fasteners on the panel face and removing the refill cap. The battery pack is removed by taking out the four (4) screws on the panel and disconnecting the power connector.

<i>Indication</i>	<i>Possible Causes</i>
High Background Reading (more than 10 ppm)	<ol style="list-style-type: none"> <li>1. Contaminated Hydrogen</li> <li>2. Contaminated Sample Line</li> <li>3. Contaminated Burner Chamber</li> </ol>
Continual Flameout	<ol style="list-style-type: none"> <li>1. Hydrogen Leak</li> <li>2. Dirty Burner Chamber</li> <li>3. Dirty Air Filters</li> </ol>
Low Air Flow	<ol style="list-style-type: none"> <li>1. Dirty Air Filter</li> <li>2. Pump Malfunction</li> <li>3. Line Obstruction</li> </ol>
Flame will not Light	<ol style="list-style-type: none"> <li>1. Low Battery</li> <li>2. Ignitor Broken</li> <li>3. Hydrogen Leak</li> <li>4. Dirty Burner Chamber</li> <li>5. Air Flow Restricted</li> </ol>
No Power to Pump	<ol style="list-style-type: none"> <li>1. Low Battery</li> <li>2. Short Circuit</li> </ol>
Hydrogen Leak (Instrument not in use)	<ol style="list-style-type: none"> <li>1. Leak in Regulator</li> <li>2. Leak in Valves</li> </ol>
Slow Meter Response	<ol style="list-style-type: none"> <li>1. Probe Not Seated Tightly</li> <li>2. Flow Rate Too Low</li> </ol>
High Reading Persists After source Removed	<ol style="list-style-type: none"> <li>1. Sample Input Line Dirty</li> <li>2. Detector Dirty</li> </ol>

**2.8 Additional Precautions**

- The calibration gas mixture must be balance in air.
- Keep battery on charger when not in use.
- Recharge battery as soon as possible after use.
- Avoid dropping the meter/probe assembly.
- **Avoid intake of high boiling vapors and all liquids.**
- Backflush the GC column after each chromatogram.
- Do not overtighten valves.
- Use zero grade hydrogen; i.e. contains less than 2 ppm hydrocarbons.
- When draining the hydrogen tank, leave a small amount in the tank.
- Whenever an OVA will not calibrate or operate properly, it is to be returned to the CDM Regional Field Equipment Manager who will arrange a replacement. Under no circumstances is field work requiring monitoring with an OVA to be done without an OVA or with a malfunctioning unit.

## SECTION 5.0 COLORMETRIC DETECTOR TUBE PUMPS

The following section outlines procedures for field operations with colormetric tube pumps.

### 5.1 Instrument Profile

**Hazard Monitored:** Specific vapors and gases.

**Application:** Determine concentration of specific vapor or gas in atmosphere. Information can be used to assess hazard and establish control measures.

**Components:** Bellows or piston pump; detector tube.

**Detection Method:** Chemical reaction with color change.

**Operation:** The sample is drawn through the detector tube at a constant flow rate. If the sample contains the vapor or gas in question it will react with the chemical on the packing material. The result of the reaction is a color change. The concentration is directly proportional to the length of the stain.

**Read Out:** The tubes normally read directly in ppm or % from a scale on the tube. Some tubes have scales in millimeters. With that type the length is read in mm and referenced on the instructions.

**Calibration:** The tubes come calibrated. The pump must be checked regularly to verify flow rate and sample volume per pump stroke.

**Inherent Safety:** None-not required.

**Limitations:** The problems which contribute to poor accuracy are:

- Leak in pump
- Insufficient contact (analysis) time
- High humidity
- High temperature
- Difficulty reading scale
- Interferences from other compounds
- Improperly stored tubes
- Out of date tubes
- Operator error

**EPA Action Guides:** None established - it depends on the toxicity of the specific chemical being monitored.

## 5.2 MSA Samplair Pump Operation

- a. Insert an unbroken tube into the orifice in the pump.
- b. Pull back and lock the pump handle. Wait sixty seconds then rotate the handle 1/4 turn. If the handle does not return to within 1/4 inch of the zero cc mark the pump is leaking and needs repaired. Do not use it.
- c. Break off the tips of a fresh colormetric indicator tube in the tube breaker hole located in the face of the pump head.
- d. Insert the tube into the tube holder with the arrow on the tube pointing towards the pump.
- e. Align the index marks located on the handle and the cap of the pump, and pull the handle straight back to the desired volume of 25, 50, 75, or 100 cc's. Refer to the individual tube's instructions. The handle will automatically lock at these volumes.
- f. Wait the required period of time, per the specific tube instructions. Read the concentration.
- h. Turn the handle 90 degrees, which releases the locking mechanism, and push the handle in.
- i. Realign the index marks for the next stroke or test.

## 5.3 Drager Pump Operation

- a. Insert an unbroken tube into the orifice in the pump.
- b. Squeeze the bellows all the way and let go but retain your grip on the pump to avoid dropping it. After sixty seconds the bellows should not have expanded. If they have, the pump is leaking. Do not use it.
- c. Break off both ends of a colormetric indicator tube in the break off eyelet, located on the front cover plate or in the break-off husk and is an accessory.
- d. Insert the opened tube into the pump head with the arrow on the tube pointing towards the pump.
- e. Hold the pump in your hand with the holding plate between the thumb and the base of the index finger, and the front cover plate contacting the fingers.
- f. Compress the bellows completely with a squeezing motion, assuring that the total volume of the bellows is used.
- g. Release the grip and allow the chain to become taut signifying a 100 cc volume of air has been pulled through the tube.
- h. Complete steps 4 and 5 as many times as indicator tube instructions state. Read the concentration as per instructions for the specific tube.

## SECTION 6.0 MODEL PDM-3 MINIATURE REAL-TIME AEROSOL MONITOR (MINIRAM)

The section outlines procedures for field operations with the Miniram Dust Monitor.

### 6.1 Instrument Profile

<b>Hazard Monitored:</b>	Airborne particulates.
<b>Application:</b>	To determine the relative concentrations of airborne particulates which may cause a respiratory hazard such as dusts, fumes, smokes, fogs, etc. Information is used to establish the level of protection and other control measures such as action levels.
<b>Components:</b>	Compact, programmable, self contained unit with removable sensing chamber; liquid crystal display read out; membrane touch switch panel; NI-CAD rechargeable battery pack; analog output; digital output; belt clip and 8 VDC charger.
<b>Detection Method:</b>	Direct light scattering aerosol optical detection sensing.
<b>Operation:</b>	The MINIRAM uses a pulsed gallium arsenide light emitting diode source. The radiation scattered by airborne particles is sensed by a silicon-photovoltaic hybrid detector. A filter is incorporated to screen out any light whose wavelength differs from that of the pulsed source. The instrument continuously senses the combined scattering from the population of particles present within its sensing volume (approximately 1 cubic cm) whose dimensions are large compared with the average separation between the individual airborne particles. Air surrounding the MINIRAM passes freely through the open aerosol sensing chamber as a result of air transport caused by convection, circulation, ventilation and personnel motion. A pump is not required for operation. The scattering sensing parameters have been designed for preferential response to the particle size range of 0.1 to 10 micrometers.
<b>Read Out:</b>	The liquid-crystal display indicates the aerosol concentration of particulates in the units of milligrams per cubic meter. The displayed reading is updated every 10 seconds. When operating in the measurement or monitoring mode, other functions can be briefly displayed.
<b>Calibration:</b>	The unit is factory calibrated against a filter gravimetric reference, using a standard test dust (Arizona road dust).
<b>Inherent Safety:</b>	The MINIRAM has been designed to satisfy the requirements for intrinsically safe operation in methane and air mixtures.

**Limitations:** Instrument is designed for quantitative analysis and therefore can only be used to give an indication of total particulate concentration.

**EPA Action Guides:** None established. It depends on the particular hazard being monitored.

## 6.2 Field Procedures

The following sections detail the procedures to be followed in the field with the MINIRAM.

<i>Procedure</i>	<i>Section</i>	<i>Frequency</i>
Zero Check	6.2.2	Prior to use
Start Up Procedure	6.2.3	Prior to use
Shut Down Procedure	6.2.6	After each use
Routine Service	6.2.7	Monthly

### 6.2.1 Controls

- MEAS** Starts the monitoring operation. Instrument will run up to 8.3 hours and will then shut down.
- OFF** Stops whatever operation the instrument was performing.
- TIME** Displays the elapsed time from the start of the measurement run. When pressed at the same time as the MEAS control, the instrument will operate continuously and will not automatically shut down (after 8.3 hours of operation).
- TWA** Displays the Time Weighted Average (TWA) concentration in milligrams per cubic meter since the start of the run.
- SA** Displays an 8-hour TWA.
- PBK** With the instrument in the OFF mode, displays its stored data. If pressed for less than one second, the information will be relayed through the digital output jack for printout, magnetic storage, or telemetry.
- ZERO** While operating, displays the stored zero value. To rezero the instrument, press OFF and then press ZERO. The next four consecutive ten second measurements are averaged and stored as the zero reference value. Wait until the display reads OFF before continuing measurements.
- ID** Displays the Instrument Identification number.

### 6.2.2 Zero Check

- In a known dust free area, press OFF.
- Depress ZERO and wait for the display to read OFF. The instrument zero is now reset.

### 6.2.3 Start Up Procedure

- a. If the display is blank, press OFF and wait for the display to read OFF. Press MEAS to begin the measurement cycle. The first reading displayed will be GO followed by the last reading or 0.0. After 36 seconds, the first new 10 second-averaged reading will be displayed. The instrument will run for 8.3 hours (on a full battery charge) or until the operator presses OFF. The readings will be in the 0.00 to 9.99 milligrams per cubic meter range. If the ten second average exceeds 9.99 milligrams per cubic meter, the display will shift to 0.0 to 99.9 milligrams per cubic meter.
- b. If the display reads OFF, press MEAS to begin the measurement cycle.

### 6.2.4 Operation

- a. Follow the zero check and start up procedures.
- b. Monitor the work activity as specified in the Site Health and Safety Plan.
- c. The reading displayed on the instrument is updated every ten seconds.

### 6.2.5 Overload and Error Code Indicators

There are three bar indicators on the MINIRAM display, identified as OVR, ID, and BAT. If the OVR bar is displayed at any time during operation in the measurement mode, the detection circuit has been overloaded. A momentary overload can be caused by the insertion of an object into the sensing chamber, sudden exposure to sunlight, etc. If the cause of the overload is eliminated, the OVR bar will disappear during the next 10 second display period, unless the overload persists for more than a total of 1 1/2 minutes over an 8.3 hour measurement cycle. If an overload condition does persist for more than 1 1/2 minutes, the OVR bar will remain on for the remainder of the run signifying an invalid measurement cycle.

To correct this, first eliminate any known cause of the overload. If the display will not return to normal, press OFF and wait five minutes. Then press MEAS. The instrument should begin a normal measurement cycle. If it does not, contact the CDM Regional Field Equipment Manager. Do not use the instrument to take measurements.

The MINIRAM will display and output (at the digital output jack) error code numbers along with the corresponding overload indicator bars on the LCD read out. These codes will appear only if the problem persists for more than about 30 seconds. The error code numbers are as follows:

- .01 : low battery condition
- .02 : RAM (digital processing)
- .03 : A/D (signal) overload

### 6.2.6 Shut Down

- a. At the end of the activity being monitored or the end of the run, press OFF. The display will read OFF.
- b. Place the instrument in its protective case to prevent dust from accumulating in the sensor and place the instrument on charge.

### 6.2.7 Service

Over time the Miniram's performance will be affected by the slow build up of dust in the sensor. Because of this the Miniram must be serviced and cleaned regularly. Therefore, the instrument is not to be left in the field for more than one month at a time before being serviced. Should the instrument become erratic in its performance, it is to be returned immediately to the CDM Regional/Subsidiary Field Equipment Manager who will arrange the service.

## 6.3 Servicing Procedures

The following section covers those activities which are to be performed by the CDM Regional Field Equipment Manager or a trained designee. CDM field personnel are not to attempt these procedures under any circumstance.

The appropriate calibration/maintenance form is to be filled in completely whenever a Miniram is serviced (Exhibit D) and a new calibration sticker attached.

The FPC Field Equipment Manager is responsible for arranging all repairs which cannot be done by the CDM Regional Field Equipment Manager and for arranging all factory service.

### 6.3.1 Routine Service

<i>Procedure</i>	<i>Section</i>	<i>Frequency</i>
Battery Pack Replacement	6.3.2	As needed
Cleaning Sensing Chamber	6.3.3	Monthly

### 6.3.2 Battery Pack Replacement

- The battery pack is an intrinsically safe, sealed unit. To remove it, remove the four central screws from the back of the Miniram case, (not the two corner screws) and gently lift the battery pack up and out and gently pull apart the battery connector, freeing the battery pack.
- To install the new battery pack, follow the above procedure in reverse order.
- Fill in the calibration/maintenance log.

### 6.3.3 Sensor Cleaning

- Carefully slide the sensor chamber off of the top off of the instrument. Be extremely careful not to touch the lens or the inside of the chamber.
- Carefully wash the chamber with a mild soap (Ivory) and water. Do not use solvents or rub the inside of the sensor chamber.
- Allow the chamber to air dry completely and place back on top of the instrument. Return the instrument to its case and place on charge if necessary.
- Fill in a calibration/maintenance log.

# GENERAL USE CALIBRATION/MAINTENANCE FORM

Date: \_\_\_\_\_ Time: \_\_\_\_\_  
 Name: \_\_\_\_\_ Region: \_\_\_\_\_ Site: \_\_\_\_\_  
 Equipment type: \_\_\_\_\_ Model.: \_\_\_\_\_  
 EPA Tag no.: \_\_\_\_\_ Serial no.: \_\_\_\_\_  
 Last used at region: \_\_\_\_\_ Site: \_\_\_\_\_  
 Last Calibrated by: \_\_\_\_\_ Region: \_\_\_\_\_ Date: \_\_\_\_\_

## CONDITION OF UNIT

Were any PARTS/ACCESSORIES missing or damaged ☐ yes ☐ no

if YES, list & describe: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Was unit returned CLEAN and in WORKING order ☐ yes ☐ no

if NO, describe condition: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

## FUNCTION TEST

Batteries good/charged: ☐ yes ☐ no      Batteries replaced: ☐ yes ☐ no

Instrument calibration: (describe method of calibration)  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Repair Section: List repairs made/parts replaced (if none write "NONE"):  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

# **Water Level Meter: Operating Instructions**

**Models 101 & 102**

**Upon receipt of meter the following operational checks should be performed:**

1. Set toggle switch to "on" or turn rotary dial fully clockwise.
2. Submerge the electrode (probe) in tap water. This completes the circuit and activates the buzzer.
3. Depress button to test the battery and circuitry (excluding the probe).

## **Water Level Measurement**

### **Zero Measurement Point**

**Model 101**      tip of the inner electrode visible near the centre of the probe  
**Model 102**      base of the outer body electrode

- clockwise rotation of rotary dial turns meter on and increases sensitivity.
- always set switch to the highest sensitivity position, then decrease if necessary.

**Note:** The P4 Probe has been designed to allow substantial submergence. Use of the P1, P2 or P3 probes to sound the bottom of the well may cause water to enter the probe.

## **Routine Care of the Water Level Meter**

1. After the depth of water has been recorded the cable should be carefully rewound onto the reel, the probe wiped dry and replaced into the probe holder.
2. The probe, cable and reel can all be cleaned with soap/detergent and water.
3. Use of a Water Level Meter Carrying Bag adds to the service life of the meter.
4. Use of a Tape Guide adds to the life of the tape.

## **Care of P4 Probe**

**Note:** Do not remove or twist the strain relief pieces as this will cause damage to the pressure seal. If the pressure seal integrity is in question, please call Solinst for the authorized repair centre nearest you.

1. While holding firmly onto the black Delrin section on the top of the probe, turn clockwise slightly and pull the P4 sleeve body down.
2. Remove all dirt and water from inside the sleeve body, the centre electrode and the Teflon pieces.
3. Remove and clean the O-rings. Clean the recessed areas and check the O-rings for damage. Lightly lubricate and replace the O-rings.
4. Carefully pull the coil spring from its recessed area and onto the centre electrode. The coils of the coil spring must curve clockwise.
5. Clean the recessed area where the coil spring rests and check to see that the exposed wire is in place and clean.
6. Push the coil spring back into place.
7. Turning clockwise, push the sleeve body over the electrode to the black Delrin piece.
8. To test, turn the unit on and lower the probe into a glass of water. When the probe touches water, the buzzer will sound and the light will come on.

### Troubleshooting

SYMPTOM	CAUSE	REMEDY
No sound when probe immersed in water.	Dead battery.	Replace with 9v Alkaline.
	Water conductivity is very low.	Increase sensitivity switch setting (turn clockwise) or call Solinst for assistance.
	Disconnected wires on circuit board.	Check all connections inside hub of reel for loose/disconnected wires - solder or reconnect.
	Broken wire in tape.	Locate break in tape - splice and seal.
	Disconnected wire inside probe.	Contact Solinst to obtain parts / repair instructions.
Continuous sound after probe is removed from water.	Water conductivity is very high.	Decrease sensitivity switch setting (turn counter-clockwise).
	Damaged components or improper wiring on circuit board.	Contact Solinst to obtain parts / repair instructions.

### Battery Replacement

- battery type - alkaline, 9 volt.

1. The battery is housed in the reel hub and is replaced by removing the front plate of the reel.
2. To remove front plate, unscrew three faceplate screws and carefully lift off to the side to avoid damage to wiring.
3. Remove battery and put in new one, making sure the polarity is correct.
4. Replace faceplate of the reel and screws, making sure the wires are fully inside.

**INSTRUCTION MANUAL  
DIGITAL CONDUCTANCE, TEMPERATURE  
AND pH TESTER, CATALOG No. 015235  
Celsius No. 016495**

**Parameters:**

**Conductance** 4 ranges

0 - 20  $\mu$  / cm

0 to 200  $\mu$  / cm

0 to 2,000  $\mu$  / cm

0 to 20,000  $\mu$  / cm

Integral sample cup

Accessible internal calibration potentiometer

Standard solution available:

500 ml. Bottle of .01 Molar Potassium

Chloride 1413 micromhos @ 77°F. (25°C)

**pH** 0 to 14 range

Slope and zero adjustments on face of unit

External electrode (purchased separately)

Buffer solution kit available, includes:

Buffer solutions, 4, 7 and 10 pH

Bottle of (distilled) water for rinse

**Temperature** 0 to 160°F (2.5 to 70°C)

Integral sample cup

**Accuracy** Conductivity  $\pm$  2% Full scale at 77°F (25°C)

Temperature  $\pm$  2°F (1°C)

pH  $\pm$  .01 pH units at 77° F (25°C)

**Operating Instructions:**

1. Rinse the inside of sample cup with liquid to be measured. (This is especially important if samples with a wide range of conductivity or pH are to be measured.)
2. Fill sample cup. (see Figure 1),

**CAUTION: THE MAIN BODY IS NOT WATER-PROOF**  
(Do not subject unit to splashing water).

**CAUTION: UNIT DESIGNED FOR AQUEOUS SOLUTIONS ONLY!**

3. Fill sample cup at least 2/3 full. If the sample is hot boiler water, allow to cool to 160°F, or below.
4. Slide the right hand function switch to "TEMP" and push the "READ" button. If temperature reading is not stable, empty & refill cup several times to bring cup and sample to the same temperature.
5. Read the temperature on the digital display panel and adjust both temperature compensation knobs accordingly.
6. If the approximate conductance is known, slide the left hand range selector switch to the proper range.

Example: If you expect the sample to be around 2000 micromhos, slide the left hand selector switch to x1000.

7. Slide the right hand function switch to "COND" and push the "READ" button.

8. Multiply the digital display reading by the factor indicated by the position of the left hand range switch to determine conductance.

Example: A display reading of 1.00 with the left hand range selector switch indicating  $\times 1000$  is:

$$1.00 \times 1000 \text{ or } 1000 \mu / \text{cm}$$

Note: If a single "1" appears on the left hand side of the digital display, the sample conductance is higher than the selected range. Slide the left hand (range) selector switch in one step intervals until a 3 or 4 digit display appears.

Conversely, if a decimal display appears (such as 0.11) move the range selector switch to the left until a 3 or 4 digit number, 1.00 or larger, appears on the display. This puts the unit in a range affording the best accuracy. Caution: A single "1" always means that the conductance is higher than the selected range.

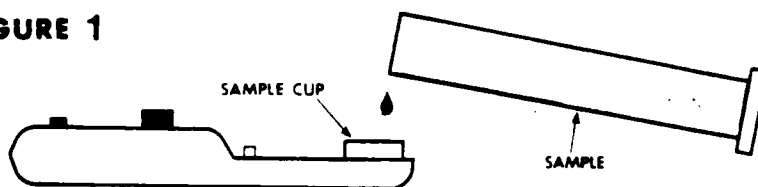
9. Slide the right hand function selector switch to "pH".
10. Insert the pH cable connector onto the tester. Push on and twist clockwise.
11. Remove the tape from the plastic storage cap.
12. Remove the plastic storage cap slowly.
13. Place the pH electrode in the sample cup or any non-metallic container holding the remainder of the sample to be measured. If you use the tester's sample cup, you will have to hold the electrode.

14. Press the "READ" button: pH value will appear on the digital display.

15. Always obtain conductivity reading before placing pH probe in sample cup. pH probes tend to carry contamination over into the sample.

**CAUTION:**  
The main body is not waterproof.

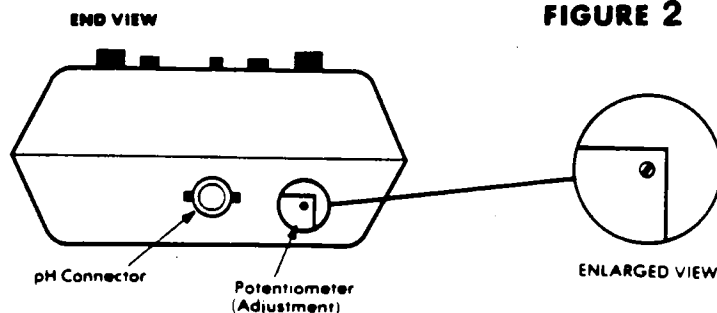
FIGURE 1



---

## CONDUCTIVITY CALIBRATION

FIGURE 2



## **CALIBRATION**

Temperature and Conductance are factory calibrated. You may check conductance accuracy with a solution of known conductance and recalibrate, if necessary.

See Figure 2. To recalibrate conductance, remove black plug revealing the adjustment potentiometer screw. Add standard solution to cup, discard and refill. Repeat procedure until the digital display indicates the same value twice in a row. Adjust the potentiometer until the digital display indicates the known value of conductance. To increase the digital display reading, turn the adjustment potentiometer screw counterclockwise (clockwise to decrease).

To standardize the pH electrode and meter, place the pH electrode in the 7.0 buffer bottle. Adjust the "ZERO" potentiometer on the face of the tester so that the digital display indicates 7.00.

Then place the pH electrode in the 4.0 or 10.0 buffer bottle (depending on where you expect the actual measurement to be). Adjust the "SLOPE" potentiometer on the face of the tester so that the digital display indicates the value of the buffer chosen.

NOTE: There is interaction between the "ZERO" and "SLOPE" adjustments, so the procedure should be repeated several times.

**DO NOT SUBJECT THE pH ELECTRODE TO FREEZING TEMPERATURES!**

It is good practice to rinse the electrode in distilled water when going from one buffer to another. When not in use the cap should be kept on the electrode. Keeping the cotton in the cap moist will keep the electrode ready to use. Moisten the cotton frequently (once a week, usually).

### **Maintenance**

#### **Battery replacement**

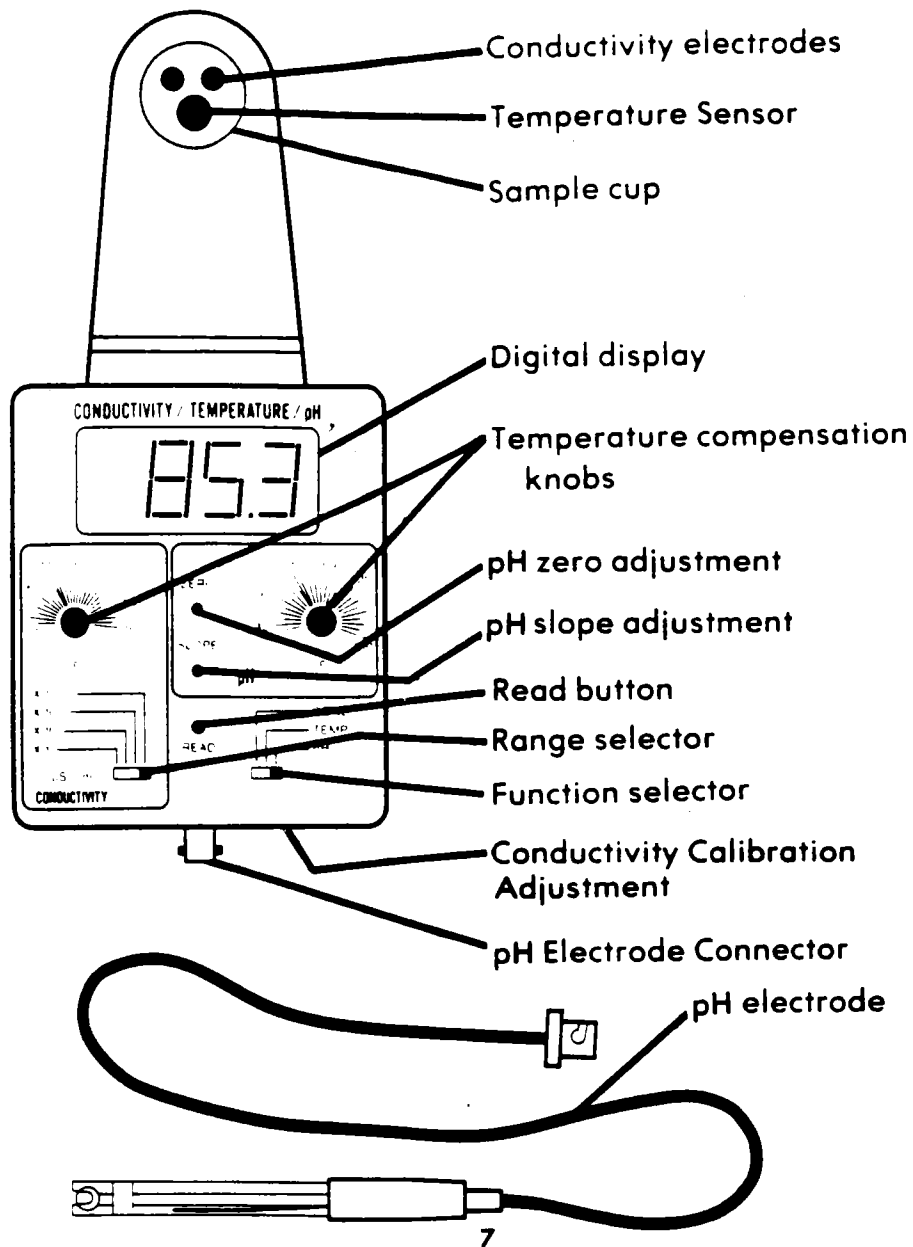
The battery is located behind the snap-off cover on the bottom of the tester. Use a small tool to pop out the cover. Replace battery with a 9 volt ; an alkaline battery such as Duracell MN 1604. Replace the battery whenever "LO BAT" appears on the display.

#### **Sample cup:**

The carbon electrodes in the cup may be cleaned with a mild abrasive, 400 grit or finer on the end of the flat surface.

**SPECIAL NOTE:** To avoid ever having to resort to harsher methods of cleaning, when rinsing cup out with liquid to be measured, wipe cup with paper towel or kleenex and rinse again.

Wipe cup after every sample and rinse with tap water when possible.





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Leaders in Electromagnetics



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*EM31*

*OPERATING MANUAL*

NOTE TO EM31 AND EM34 USERS:

Through the normal course of operation, it is possible that the battery contacts will become contaminated with dirt and grit. To clean these contacts use fine sand paper (#400 or higher) and wipe several times over the contact.

Ensure that the spring action of the battery holders is maintained. Bend holder sides slightly if necessary.

### EM31 SPECIFICATIONS

MEASURED QUANTITIES	(1) Apparent conductivity of the ground in milliSiemens per meter (mS/m) *
	(2) Inphase component in parts per thousand (ppt) of the ratio of the secondary to primary magnetic field.
PRIMARY FIELD SOURCE	Self-contained dipole transmitter
SENSOR	Self-contained dipole receiver
INTERCOIL SPACING	3.66 meters
OPERATING FREQUENCY	9.8 kHz
POWER SUPPLY	8 disposable alkaline "C" cells (approx. 20 hrs. life continuous use)
CONDUCTIVITY RANGES	3, 10, 30, 100, 300, 1000 mS/m
MEASUREMENT PRECISION	+2% of full scale
MEASUREMENT ACCURACY	+5% at 20 mS/m
NOISE LEVELS	0.1 mS/m, 0.03 ppt
DIMENSIONS	Boom : 4.0 meters extended : 1.4 meters stored Shipping Case : 144x21.5x36 cm
WEIGHT	Instrument Weight : 11 kg Shipping Weight : 24 kg

*\* MilliSiemens per meter (mS/m) are the same as millimhos per meter (mmho/m)*

# EM31 OPERATING MANUAL

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January 1991

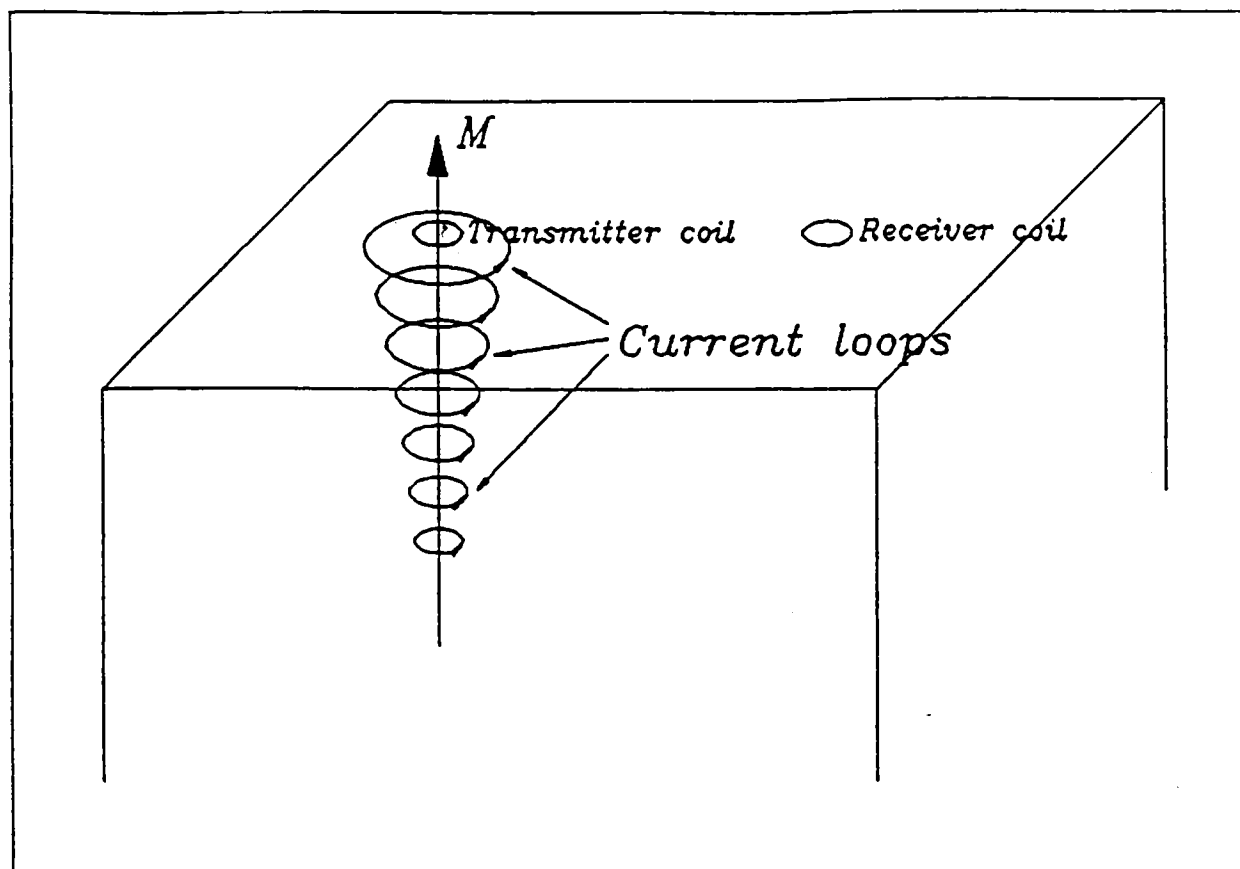
## 1.0 INTRODUCTION

Measurement of ground resistivity is one of the oldest geophysical techniques. Table 1, taken directly from Heiland\*, lists typical values of resistivity for a variety of geological materials (pages 4-8). The values given are in ohm-centimeters and must be divided by one hundred to give ohm-meters.

It will be observed that in most cases the actual resistivity itself is not diagnostic and a knowledge of the way in which the resistivity varies laterally and with depth is of great importance, since this permits us to "see" features as a result of their shape rather than their actual resistivity values. There is thus a requirement for instrumentation which permits the rapid and accurate measurement of terrain resistivity. Since the EM31 does not require electrical contact with the ground it fulfils this objective.

The basic principle of operation of the EM31 is simple. With reference to Figure 1 a transmitter coil located at one end of the instrument induces circular eddy current loops in the earth. Under certain conditions fulfilled in the design of the EM31 the magnitude of any one of these current loops is directly proportional to the terrain conductivity in the vicinity of that loop. Each one of the current loops generates a magnetic field which is proportional to the value of the current flowing within that loop. A part of the magnetic field from each loop is intercepted by the receiver coil and results in an output voltage which is therefore also linearly related to the terrain conductivity.

\* Heiland, C.A. *Geophysical Exploration*. Hafner Publishing Co., New York 1968



*Figure 1: Induced Current Flow in Ground*

This instrument is calibrated to read the correct conductivity when the earth is uniform. In the event that the earth is layered, with each layer of different conductivity, the instrument will read an intermediate value as discussed in more detail in Section 5.2.

The unit of conductivity used is the millimho per meter (the same as millisiemens per meter). To obtain resistivity in ohm-meters the instrument reading is divided into 1000 - i.e., a reading of four millimhos per meter divided into 1000 gives two hundred and fifty ohm-meters.

## 1.0 INTRODUCTION (Cont'd)

Theoretical calculations show, as will be quickly evident to the operator, that the reading obtained is essentially independent of the orientation of the instrument with respect to the earth. There is, however, a small dependence on the height above the ground; lifting the instrument from the surface of a uniform earth to the normal operating height of about one meter results in a reduction in the reading of 12%. The calibration has been adjusted at the factory so that the instrument reads correctly over a uniform half-space when worn as shown on page 13. If the earth is layered, raising the instrument from the surface of the earth to the normal operating position can result in a reading which stays constant or even increases slightly with height. In general readings made with the instrument at hip height will be sufficiently accurate, but for maximum accuracy the instrument can be laid on the ground as will be discussed in Section 5.2.

There are two components of the induced magnetic field measured by the EM31. The first is the quadrature-phase component which gives the ground conductivity measurement as described. The second is the inphase component used primarily in the EM31 for calibration purposes. The inphase component, however, is significantly more sensitive to large metallic objects and hence, very useful when looking for buried metal drums (see Section 2.2).

RESISTIVITIES OF IGNEOUS & METAMORPHIC ROCKS													
Rock	LOCALITY	INVESTIGATOR	Dia.	Frag.	RESISTIVITY IN OHM-CM								
					Intermediate Conductors								
					$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{3}{32}$	$\frac{1}{16}$	$\frac{3}{64}$	
<i>Specimens</i>													
Diabase	Idaho	Sundberg	3				3.1						
Granite	Bavaria	Hunkel	3							1			
Devonian slate	Harz	Ebert					2						
"	"	"						6.5					
Porphyry, schistose	S. Australia	Edge & Laby		100			3						
Serpentine		Eve & Keys					3-2						
Diorite	Bavaria	Hunkel	3				1						
Gabbro	Mineville	Lee & Boyer		D.C.					1.0	—	1.4		
Garnet gneiss	Bavaria	Hunkel	3						2				
Hornblende gneiss	Mineville	Lee		D.C.						1-6			
Gray biotite gneiss	"	Lee & Boyer		D.C.							4		
Syenite	Bavaria	Hunkel	3								1		
<i>In Situ</i>													
Graphitic schist	Normandy	Schlumberger		16	1-1								
Schists	Missouri	Poldini			2-6								
Hard calc. schist	Belgian Congo	Geoffroy & Charrin					2-1.1						
Mica schist (hard packed)	Washington, D. C.	Gish & Rooney		16			1.3						
Quartz porphyry (slightly altered)	Newfoundland	Kihlstedt				3.4							
Keweenaw lavas	Michigan	Hotchkiss, et. al.		10-15	1.2	—	4.4						
Greenstone	"	Rooney		16		1.1							
Porous trap-rock	"	"		16		1.6							
Pre-Cambrian Granite	Sweden	Sundberg					3-6						
	Washington, D. C.	Gish & Rooney		16			5						
Slightly altered syenite	Ontario	Kihlstedt		200			2.4						
							3.7						
Massive vein quartz	"	"		200				2					
Diabase	Michigan	Rooney		16		4.5							
Serpentine	Ontario	Kihlstedt		200		2.1							
						5.3							

Table 1A: Resistivities of Igneous and Metamorphic Rocks

RESISTIVITIES OF CONSOLIDATED SEDIMENTS <sup>a</sup>										
Rock	LOCALITY	INVESTIGATOR	DIP.	FREQ. $\mu$	RESISTIVITY IN OHM-CM					
					10 <sup>2</sup>	10 <sup>3</sup>	10 <sup>4</sup>	10 <sup>5</sup>	10 <sup>6</sup>	10 <sup>7</sup>
<i>Shales and Slates</i>										
Chattanooga shale (Dev.)	Cent. & south Illinois	Hubbert		50		2	—	1.4		
Shale & glacial drift	"	"		50		5				
Nonesuch shale	Houghton Co., Mich.	Hotchkiss, et. al.		10-15			1.8			
Shale	W. Hancock, Mich.	Rooney		60				2		
Slate		Lee, Joyce, & Boyer		0			6.4			
Clay (wet)	Jugoslavia	Loehnerberg & Stern		D.C.		2.1				
Grinneld argillite	N $\frac{1}{2}$ sec. 23, T32N R20W, Flathead Co., Montana	Erdmann	dip 32°	16						
				10			1.7			
			to stratification	20		9.6				
				20			1.1			
				30			1.0			
			⊥ to strike	10		8.7				
				20		7.4				
				40			1.1			
Grinneld argillite	" (Water's Edge)	"	dip 32°	16						
				15			1.3			
			to strike	30			1.4			
							8.0			
							8.2			
				10			7.7			
Argillite (Missoula group); pre-Cambrian, thin-bedded, platy argillite; resembles Grinneld	Sec. 27, T 32N R20W, Flathead Co., Montana	"	dip 31°	16						
				10			1.4			
				20			1.6			
			⊥ to strike	30			1.5			
				40			1.4			
				50			1.5			

Table 1B: Resistivities of Consolidated Sediments

## RESISTIVITIES OF CONSOLIDATED SEDIMENTS

Rock	Locality	Investigator	Dip	Pore %	a <sup>2</sup>	Resistivity in ohm-cm					
						10 <sup>2</sup>	10 <sup>3</sup>	10 <sup>4</sup>	10 <sup>5</sup>	10 <sup>6</sup>	10 <sup>7</sup>
<i>Conglomerates</i>											
Great conglomerate outcrop	Eagle Harbor, Mich.	Hotchkiss, et al.		10-15					1.1		
Calumet & Hecla conglomerates	Michigan	Rooney		60					2	1.3	
<i>Sandstone</i>											
Eastern sandstone	Michigan	Hotchkiss, et al.		10-15			3.5-1.2				
Eastern sandstone	"	Rooney		16			4.3				
Muschelkalk ss. (Triassic)	Lorraine	Schlumberger		16			7				
Sandstone (Tertiary Oligocene); soft, friable; extremely fine grained ss.; pale green to yellowish and buff; contains thin beds of lignite	Coal Creek Road, Flathead Co., Montana	Erdmann	dip = almost 0	16	10	8.8					
					20	9.8					
					20	6.2					
					30	6.7					
						4.8					

Table 1B (cont'd): Resistivities of Consolidated Sediments

RESISTIVITIES OF CONSOLIDATED SEDIMENTS											
Rock	LOCALITY	INVESTIGATION	Dip	Page	4°	RESISTIVITY IN OHM-CM					
						10°	10°	10°	10°	10°	10°
Armorican ss. compact Siliceous-Ordovician	Normandy	Schlumberger						1			
Ferruginous sandstone (Jurassic)	Switzerland	Koenigsberger						4			
Limestone											
Muschelkalk ls. (Triassic)	Lorraine	Schlumberger		16		6					
Limestone with lenses of hematite	Algeria	"					1.2-4				
Muschelkalk oolitic ls. (Triassic)	Lorraine	"		16			1.8				
Limestone	Mississippian (Missouri)	Poldini					3-4				
Siyeh ls., hard homogeneous, dark bluish-gray, siliceous magnesium ls.; pre-Camb.	SW cor. sec. 5 T29N R18W Flathead Co., Montana	Erdmann	dip 54°    to strike ⊥ to strike	16		10 20 30 10 20 30 50	6.8 1.4 1.5 1.4 3.6 5.4 7.9 6.6 6.9 6.1 8.1				

Table 1B (cont'd): Resistivities of Consolidated Sediments

RESISTIVITIES OF UNCONSOLIDATED FORMATIONS (MOSTLY QUATERNARY)											
FORMATION	LOCALITY	INVESTIGATOR	d	Freq.	RESISTIVITY IN OHM-CM						
					10 <sup>2</sup>	10 <sup>3</sup>	10 <sup>4</sup>	10 <sup>5</sup>	10 <sup>6</sup>	10 <sup>7</sup>	
<i>Marls</i>											
Marl & gypsum	Germany	Schlumberger		16	3-1.2						
Marl & gypsum	Algeria	"		16	1-3						
Jarnisy marls	Lorraine	"		16	5						
Marls	"	Geoffroy			7						
<i>Clay</i>											
Clays with Mg salts	Australia	Rooney		16	1-2						
Clay (wet)	Palestine	Loebenberg		D.C.	5-4						
Boulder clay (no gravel)	Montana	Erdmann	10		2.1						
			20		2.3						
Marine clay	Ontario	Hawkins			3.6						
Dry clay	New Jersey	Feldman		40 mc. <sup>b</sup>	5.1						
Wet clay	"	"			8						
Boulder clay (wet)	Montana	Erdmann	20				1.1				
<i>Alluvium and Silt</i>											
Alluvium (moist)	Montana	"	10		2.3						
Silt (dry)	"	"	5		2.0						
			10		1.3						
			20		1.4						
Glacial out-wash (dry)	Washington (state)	"	10				1.3				
" " "	"	"	10				1.6				
" " "	"	"	10				2.1				
Fluvio glacial till (wet)	"	"	20				8.4				
			40				5.7				
			60				4.9				
			100				3.9				
Glacial River gravel (wet)	Connecticut	Leonardson			5						
" " "	Montana	Erdmann	10		1.2						
" " "	"	"	10		1.4						
Yellow river sand (3.3% moisture)		Sundberg			1.7						
Yellow river sand (0.86% moisture)		"			8.3						
Stream gravel (wet)	Montana	Erdmann	10		3.3						
			15		3.3						
			20		3.2						
River gravel (wet)	Colorado	"	10		4.8						
			10		6.5						
			10		4.8						
			10		8.9						

<sup>b</sup> mc. = megacycles = 10<sup>6</sup> cycles.

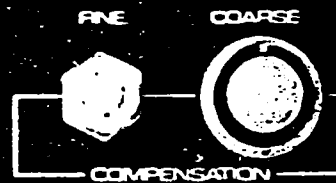
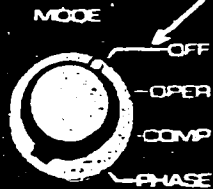
<sup>a</sup> mc. = megacycles = 10<sup>6</sup> cycles.

Table 1C: Resistivities of Unconsolidated Formations

GEONICS LIMITED  
MISSISSAUGA, CANADA

EM31

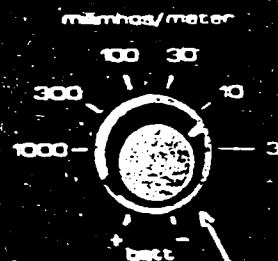
BATTERY  
PACK



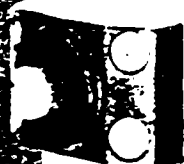
OF CONTROL

(Inside)

DC ZERO  
CONTROL



DATA  
RECORDER  
BOTTOM



## 2.0 OPERATING INSTRUCTIONS

The EM31 can be used both to measure the electrical conductivity of the ground and to detect buried metal objects. Section 2.1 describes the procedure for measuring ground conductivity and Section 2.2 for buried metal detection.

### 2.1 GROUND CONDUCTIVITY MEASUREMENTS

#### 2.1.1 Initial Set-up Procedure

- a) Before undoing the bottom holder and releasing the transmitter and receiver coil booms, check the battery condition, plus and minus, by setting the Mode switch to the OPER position and rotate the Range switch counter-clockwise to the +B and -B positions respectively. If the needle reads inside the BATT mark on the meter, the batteries are in good condition, otherwise replace the batteries with a fresh set of C size alkaline batteries.
- b) Using the identifying labels on the tubes, select the transmitter coil tube, align it with respect to the main tube, insert it and fix it with the clamp.
- c) Turn the instrument ON by setting the Mode switch to the OPER position and check the zero reading. The Range switch should be set to the least sensitive position 1,000 mmhos/meter (this minimizes any external noise interference while checking the zero position). If a zero adjustment is required adjust the DC ZERO CONTROL located under the front panel to obtain a zero reading. To do this the battery pack must be removed to gain access to the controls.

- d) Turn the instrument OFF before connecting the receiver coil, then align and connect the receiver coil tube to the main frame tube. The instrument is now ready to proceed with the functional checks.

#### 2.1.2 Equipment Functional Checks

The Range switch should be set at 30 millimhos/meter position for all the following tests. (If the reading is off scale i.e., greater than 30 millimhos/meter, see note at end of this section).

- a) Set the Mode switch to the COMP position and adjust the meter reading to zero using the COARSE and FINE COMPENSATION controls.
- b) To check the phase of the instrument set the Mode switch to the PHASE position. Note the meter reading and rotate the COARSE control one step clockwise. If the meter reading remained the same, the phase is already correct; return the COARSE control to its original position (one step counter clockwise) and no further adjustment is necessary.

If there is a difference in the meter readings taken before and after the COARSE control was rotated one step clockwise then a phase adjustment is required. With the COARSE control in its original position adjust the PHASE potentiometer about 1/4 turn clockwise and note the new meter reading. Rotate the COARSE control one step clockwise, take a reading, and return the COARSE control to its original position. If the difference in meter readings has decreased, repeat the procedure using a further clockwise adjustment, until rotating the COARSE control the one step clockwise produces no change in the meter reading.

If, on the other hand, the difference in meter readings has increased, the PHASE potentiometer should be rotated in a counter clockwise direction instead and the procedure described above repeated until there is no change in the meter readings. Always remember to set the COARSE control back to its original position. This can be confirmed by setting the Mode switch in the COMP position and checking that the meter reads zero. If it does not read zero, repeat steps (a) and (b).

- c) To check the sensitivity of the instrument, set the Mode switch to the COMP position and rotate the COARSE control clockwise one step. The meter should read between 75% and 85% (22 to 26 millimhos/meter) of full scale deflection (inside black mark). It is unlikely that the sensitivity of the instrument will vary, however, it may be useful to record the actual meter reading for comparison at a later date.

Return the COARSE switch to its original position and the EM31 is now ready to make ground conductivity measurements.

NOTE: When conducting the functional tests over ground of conductivity greater than 30 millimhos/meter, the Range switch should be set at the appropriate level. At whatever level the Range switch is in, the reading taken in (c) should still be between 22 and 26 millimhos/meter.

### 2.1.3 Operating Procedure

- a) Positioning the instrument with the shoulder strap adjusted so that the instrument rests comfortably on the hip as shown, turn the Mode switch to the OPER position and rotate the Range switch so that the meter reads in

the upper two-thirds of the scale. The instrument is now reading ground conductivity directly in millimhos per meter (mmhos/m) and full scale deflection is indicated by the Range switch. With the Range switch set at 10, 100 or 1000 mmhos/m, measurements are read from the top scale; with the Range switch set at 3, 30 or 300 mmhos/m, measurements are read from the bottom scale.



*Normal Operating Position - Vertical Dipoles*

- b) The instrument can be operated in either of two dipole modes - vertical or horizontal (see also Section 5.3). The instrument response, as a function of depth, varies significantly between the two modes. It is important to recognize that the vertical dipole mode provides twice the effective depth of exploration as the horizontal dipole mode - 6 m and 3 m, respectively. (A complete discussion of the vertical and horizontal dipole modes is provided in Geonics Technical Note TN-6).

The instrument, as shown, is being operated in the vertical dipole mode. Note that the faceplate of the console is horizontal. To operate in the horizontal dipole, the instrument is rotated 90° over the long axis such that the instrument is on its side, the faceplate is vertical and facing into the side of the operator.

"Normal" operating position is considered the vertical dipole mode, usually at hip height. When measurements in the horizontal dipole mode, only are desired, the instrument should be placed on the ground surface. Should both vertical and horizontal dipole measurements be desired for comparative purposes, the instrument should be placed at ground surface for both readings.

- c) When collecting discreet data points the operator can extend battery life by turning the instrument off between stations. In this case, the operator will notice a slight initial overshoot of the needle at turn on. This is normal, and at least two seconds should be allowed after initial turn on before the measurement is recorded.

Alternatively, the operator may choose to leave the instrument on and watch for anomalous readings between data points. The instrument, however, has a time constant of about one second for which the operator should adjust his walking speed to obtain greatest accuracy.

It is also possible to collect continuous data along any transect with the use of a digital or analog data recording system. Again, the effect of the instrument time constant should be recognized. With either digital or analog recorder, fiducial marks can be placed within the data as fixed points of reference.

The orange button on the transmitter boom is used only in conjunction with the data recording systems.

(Instructions for the use of all features related to the data recording systems are detailed in the appropriate recorder operations manuals).

## 2.2 BURIED METAL DETECTION

### 2.2.1 Set-up and Operating Procedure

The inphase component of the induced magnetic field is significantly more sensitive to large metallic objects than the quadrature phase (quad-phase) component used for ground conductivity measurements.

Typically, the EM31 inphase component will detect a single 55 gallon drum to depths of about 2 meters to the top of the drum. Under certain circumstances, however, single drums have been detected to depths of about 3.5 meters.

- a) The inphase component is measured directly by setting the MODE switch to the COMP position, rather than the OPER position which is used for quad-phase measurements.

Inphase measurements are the ratio of the induced secondary magnetic field to the primary magnetic field in parts per thousand (ppt). With the instrument in the COMP position, meter readings are multiplied by 0.23 to obtain the inphase component in ppt.

- b) Experience has shown that the 30mmho/m range provides the optimum Range setting and sensitivity for most geological backgrounds.

To carry out a survey measuring the inphase component set the Mode switch to the COMP position and adjust the COARSE and FINE COMPENSATION controls so that a meter deflection of about 40% of full scale is obtained. (This procedure will establish a background reference level, allowing for both positive and negative meter deflections to be displayed.)

(It should be noted that a sudden jar to the instrument can result in a small positive or negative change in the reference level).

The lack of a true zero reference should not cause any serious difficulty or confusion with interpretation since metal targets are generally recognized by anomaly signatures in the data.

As an example, Figure 3 shows a typical inphase, and quad-phase response when the instrument is carried over a metallic pipeline. Variability in the shape, depth and orientation of the target will alter the shape of the anomaly. These anomalies can be characterized by increasing or decreasing, and possibly negative values or some combination of each.

- c) The inphase zero offset described above, is only used to allow the observation of negative meter deflections against some arbitrarily determined reference level. This offset should not be used when both inphase and quad-phase components are measured at each station; in this case, the set-up procedure is the same as outlined in section 2.1.2 (a).

**NOTE:** It is always advisable, when surveying for buried metal to measure both the inphase and quad-phase components. While the inphase, in general, is a better detector of

metal, the quad-phase is more sensitive to long, extended targets (eg. pipelines) which are, at least partially, in electrical contact with the ground.

### 3.0 INSTRUMENT CALIBRATION

Prior to shipping, the instrument is calibrated in the factory to read properly. If necessary, calibration procedures are easily carried out as described below. IMPORTANT - The most critical adjustment is the QF (quadrature fine) potentiometer which has been precisely adjusted at the factory.

Before any adjustments are made it is strongly recommended that the instrument first be set up at a fixed height over a known location and the ground conductivity carefully noted. If this adjustment is misaligned the instrument will have to be recalibrated over ground of known conductivity.

#### 3.1 Null Calibration

The zero setting of the EM31 can be readily set by following the procedure described in Section 2.1.1 (c).

#### 3.2 Absolute Calibration

Absolute instrument calibration is easily achieved if any area of ground is available of known and constant conductivity down to the depth of penetration of the instrument. The procedure is simple; the instrument is located over the known area at the usual operating height (approximately 1m) and the QF compensation control is adjusted until the meter reads the correct terrain conductivity. If the ground conductivity is high, Figure 2 must be used to correctly set the instrument

reading.

It is wise to maintain such an area as a calibration check area even if the variation of the conductivity with depth at that area is not accurately known. This is useful for cross checking with future measurements.

*NOTE: The QF and NULL controls are located under the front panel. Battery pack must be removed to gain access.*

#### 4.0 SURVEY TECHNIQUE

Surveying with the EM31 is straightforward. As pointed out in 2.1.3. (c) measurements may be made either continuously or on a station-by-station basis. In either case it is always recommended, as for any other geophysical survey, that survey lines and measurement stations be carefully laid out, and the survey performed in a systematic fashion with the resulting data accurately plotted for each measurement station. The most common survey error is to have the survey lines too short, in which case they do not extend sufficiently far off the expected anomalous region to permit the operator to establish the background values of terrain conductivity.

The decision as to the correct spacing will be based on a knowledge of the lateral dimension of the anticipated resistivity anomaly. To ensure the correct spacing, it is useful at the start of the survey to continuously observe the conductivity values that are encountered as the operator moves down the survey line.

The resolution in conductivity of the EM31 is also high, with changes of 5% being quickly perceived. This instrument is capable of giving an extremely precise survey with information on small variations in the terrain.

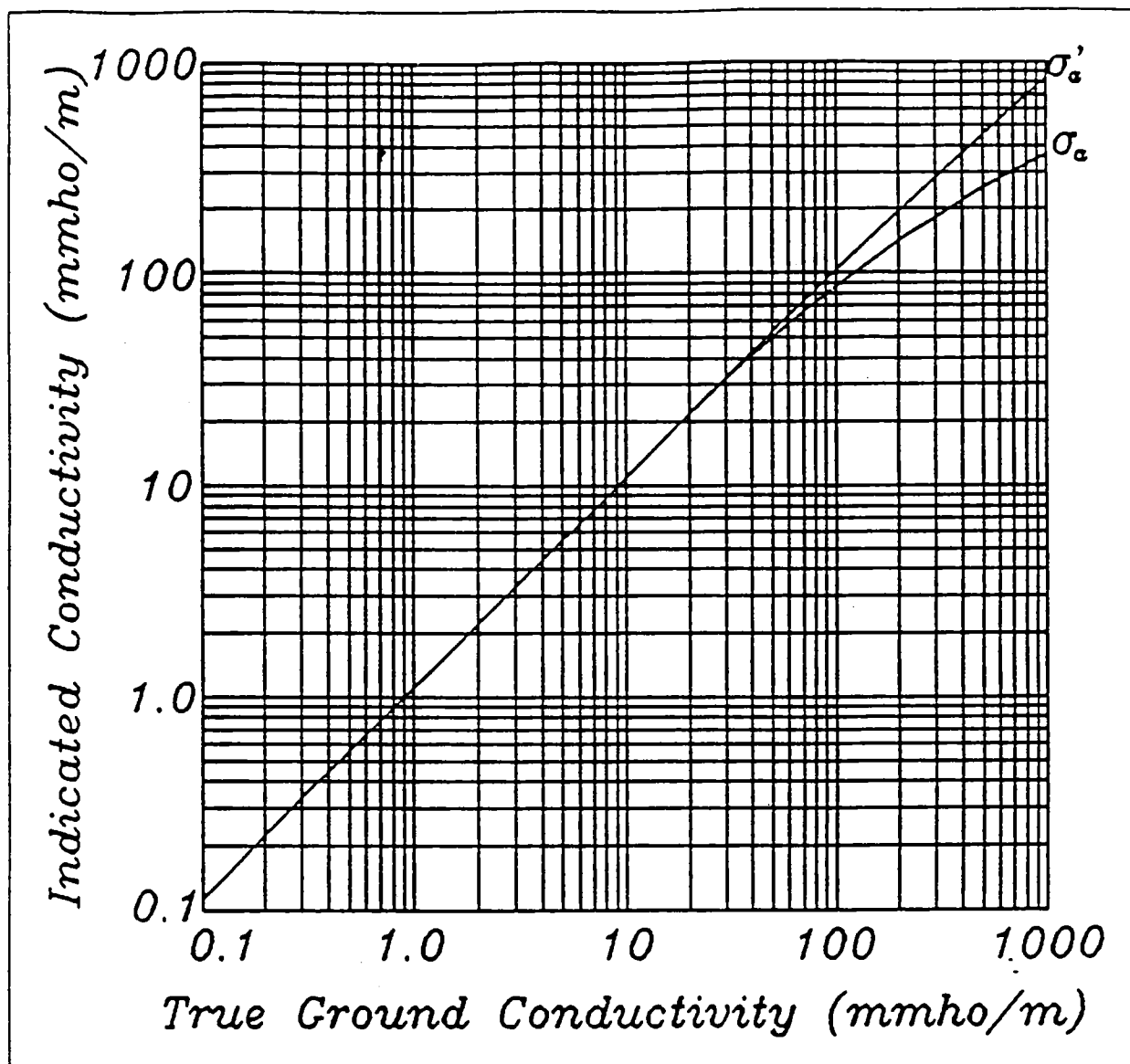


Figure 2: Conductivity Correction

#### 4.0 SURVEY TECHNIQUE (cont'd)

It was seen in Section 1 that current flow within the earth consists of a series of concentric circles, assuming that the conductivity is laterally uniform. Therefore, in the case of a uniform half-space, rotation of the instrument in a horizontal plane about the transmitter coil as a pivot will produce no change in the meter reading. Conversely, any change in the reading as this procedure is carried out is an indication of lateral inhomogeneities in conductivity. It is simpler and usually sufficiently accurate for the operator to rotate the instrument through 90° using himself as pivot at each measurement station. Thus if the lines are in a north-south direction the operator would normally walk along the line with the instrument pointing in a north-south direction; at each measurement station he can also take a reading with the instrument pointing east-west to check that this is essentially the same as the north-south reading. In the event that this reading is significantly different it may be worthwhile for the operator to then rotate the instrument to the points where the conductivity reading is both a maximum and a minimum, and to record both values. The average value can then be used for the data reduction.

The EM31 is sensitive to underground conductors such as large pipes, drums, etc. These are usually easily recognized by the large meter fluctuations which occur within a short distance, as shown in Figure 3. In an actual survey, since the negative-going peak is often off-scale, it is not possible to use it to locate the pipe; finding the point half way between the two positive going peaks approximately performs the same task. It is then possible to accurately determine the location and strike the direction (azimuth).

#### 4.0 SURVEY TECHNIQUE (cont'd)

of the conductor axis as follows: the approximate location is determined as above, and a traverse is then made over the conductor with the EM31 pointing in the approximate direction of the conductor axis. The meter reading will now be a positive maximum when the instrument is both directly over the conductor and pointing accurately along the conductor axis.

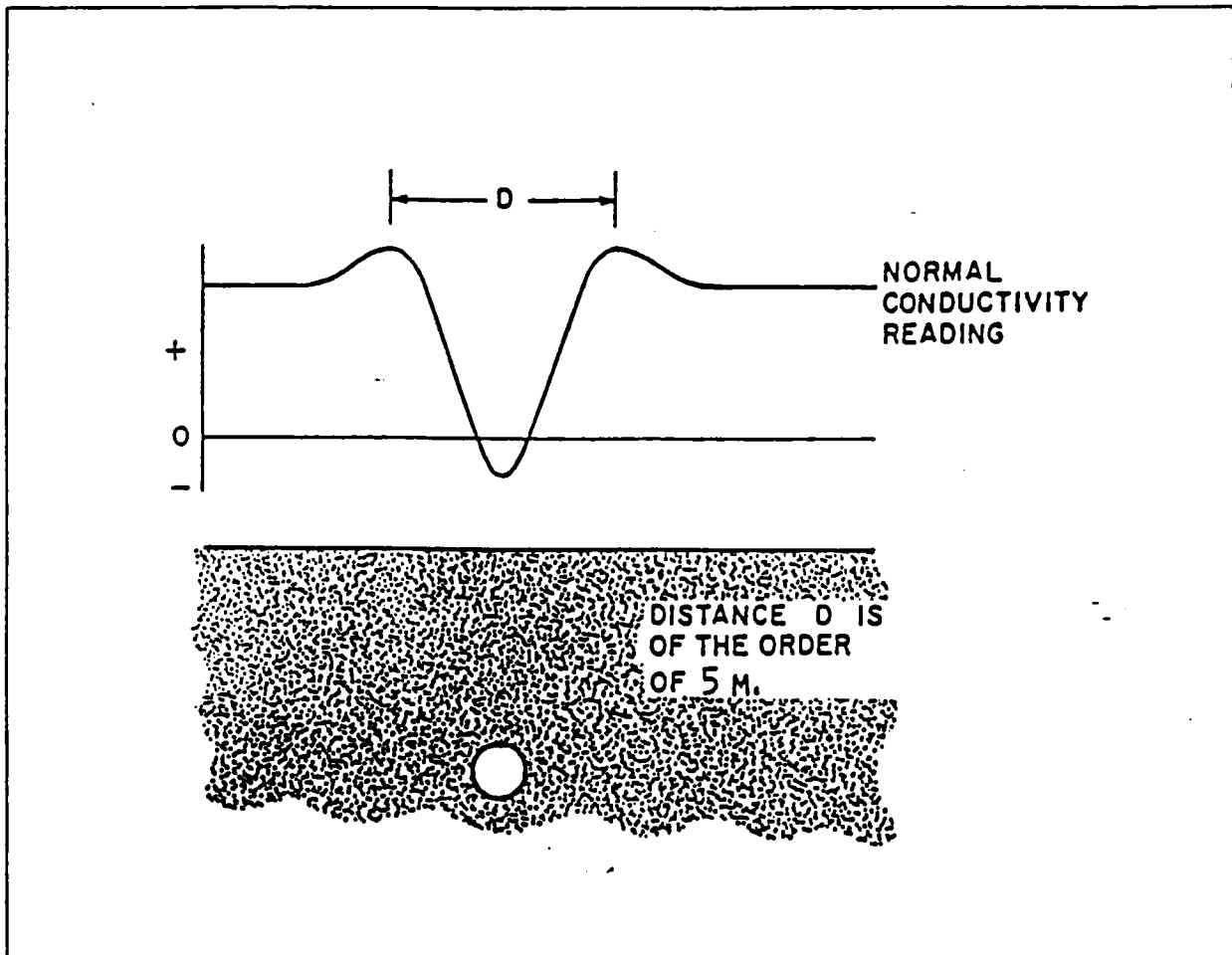


Figure 3: Typical Response over a Pipe

4.0 SURVEY TECHNIQUE (cont'd)

The instrument is relatively unaffected by fences, overhead power lines, and other nearby metallic objects. In order to determine whether the reading is influenced by such structures the operator should rotate the instrument to check for changes in reading, becoming suspicious if a maximum or minimum occurs when the instrument points either perpendicular or parallel to the structure. Before recording the measurement the operator should move away from the structure until no evidence of lateral inhomogeneity is seen when the instrument is rotated.

It should be remembered that the EM31 is an electromagnetic tool and care should be taken near obvious conductors until the operator has satisfied himself as to their possible effect. In every case this is determined by rotating the instrument and determining whether there is a maximum and minimum which appears to be related to the structure. If a structure is giving such an effect it is not advisable to take the average value of the two readings as in an indicator of the terrain conductivity.

In general the conductivity readings obtained with the EM31 will vary smoothly from one region to another. In some cases, however, as for example where a well defined vertical contact separates a poor conductor from a very good conductor, edge effects may be seen in which the readings vary rapidly with position and are no longer a good indicator of the terrain conductivity. Edge effects may also occur where a very good conductor (a few ohm-meters or less) has dimensions of the order of the intercoil spacing, and again the indicated readings may not accurately reflect the true

#### 4.0 SURVEY TECHNIQUE (cont'd)

terrain conductivity. In any circumstance where the apparent conductivity varies significantly in a distance which is short compared with the intercoil spacing the possible presence of edge effects or local subsurface conductors must be considered.

Finally, particularly during mid-summer afternoon, electrical static (electromagnetic radiation from local or distant thunderstorms) may cause the meter readings to become noisy. This is usually evidenced by sudden flicks of the meter needle, however, in very severe cases the meter may simply wander about an average reading. Should this occur it is recommended that measurements cease until the "spherics" are over, usually later in the afternoon. Similarly, noisy readings may also be noted when making measurements near large power lines.

#### 5.0 DATA INTERPRETATION

##### 5.1 Uniform Halfspace

The EM31 has been designed to operate over a range of resistivities from a few ohm-meters to thousands of ohm-meters. For higher conductivities the instrumental response departs from linearity as shown in Figure 2, where it will be seen that up to one hundred millimhos per meter the indicated conductivity ( $\sigma_i$ ) closely approximates the true conductivity. A departure from linearity is evident for true conductivity greater than one hundred millimhos per meter and beyond one

### 5.1 Uniform Halfspace (cont'd)

thousand millimhos per meter the instrument response decreases with increasing conductivity. As stated in the introduction, it is generally more informative to observe the spatial variations of terrain conductivity rather than the absolute value of conductivity itself. Figure 2 shows that even at the higher values of terrain conductivity the instrument will be adequately sensitive to small changes in conductivity although it does not read the actual value of conductivity accurately. If necessary, Figure 2 can be used to correct values of indicated conductivity to actual conductivity.

It should be noted that the graph refers to the worst case viz that of the uniform halfspace. If only a portion of the subsurface ground beneath the instrument is of high conductivity as in the case of horizontal layering, the influence of the high conductivity layers will be proportionately reduced and the indicated conductivity will accurately read the "apparent conductivity" as defined in the following section.

### 5.2 Multi-Layered Earth

A geophysical model that is of particular importance is the horizontally layered earth, and the EM31 allows a very simple interpretive technique for this model. In order to utilize the model the terrain layering must be well defined and constant over a lateral distance of at least five meters in any direction from the instrument. This condition is often satisfied and this fact is responsible for the usefulness of the technique described herein.

5.2 Multi-Layered Earth (cont'd)

Figure 4 is a plot of  $R(Z)$ , a function which describes the cumulative relative contribution of all of the material below a depth to the instrument reading. Thus, if we multiply this function by one hundred (to yield percent) all of the ground below a depth  $z$  of two meters yields 59% of the response, the ground below three meters yields 47%, the ground below six meters yields 29%, etc., assuming that the conductivity itself does not vary with depth.

The algebraic expression given on the figure illustrates the technique which is used to calculate the "apparent conductivity" that will be measured by the instrument for any number of layers, for any values of conductivity and for any thickness. Consider for example Figure 5, which illustrates in cross section a buried river valley cut into shale and subsequently infilled with glacial till. We wish to calculate the instrument response as such a structure is traversed. This is a two layer problem and the expression for the apparent conductivity reduced to:

$$\frac{\sigma_a}{\sigma_1} = 1.000 - R(Z_1) + k_2 R(Z_1) \quad (1)$$

Instrument 1 m above surface  
(i.e. normal operating height)

$$\sigma_a/\sigma_1 = 1.0 - R(z_1) + k_2[R(z_1) - R(z_2)] \\ + k_3[R(z_2) - R(z_3)]$$

$$+ k_{n+1}R(z_n)$$

where  $k_2 = \sigma_2/\sigma_1$ ,

$k_3 = \sigma_3/\sigma_1$ , etc.

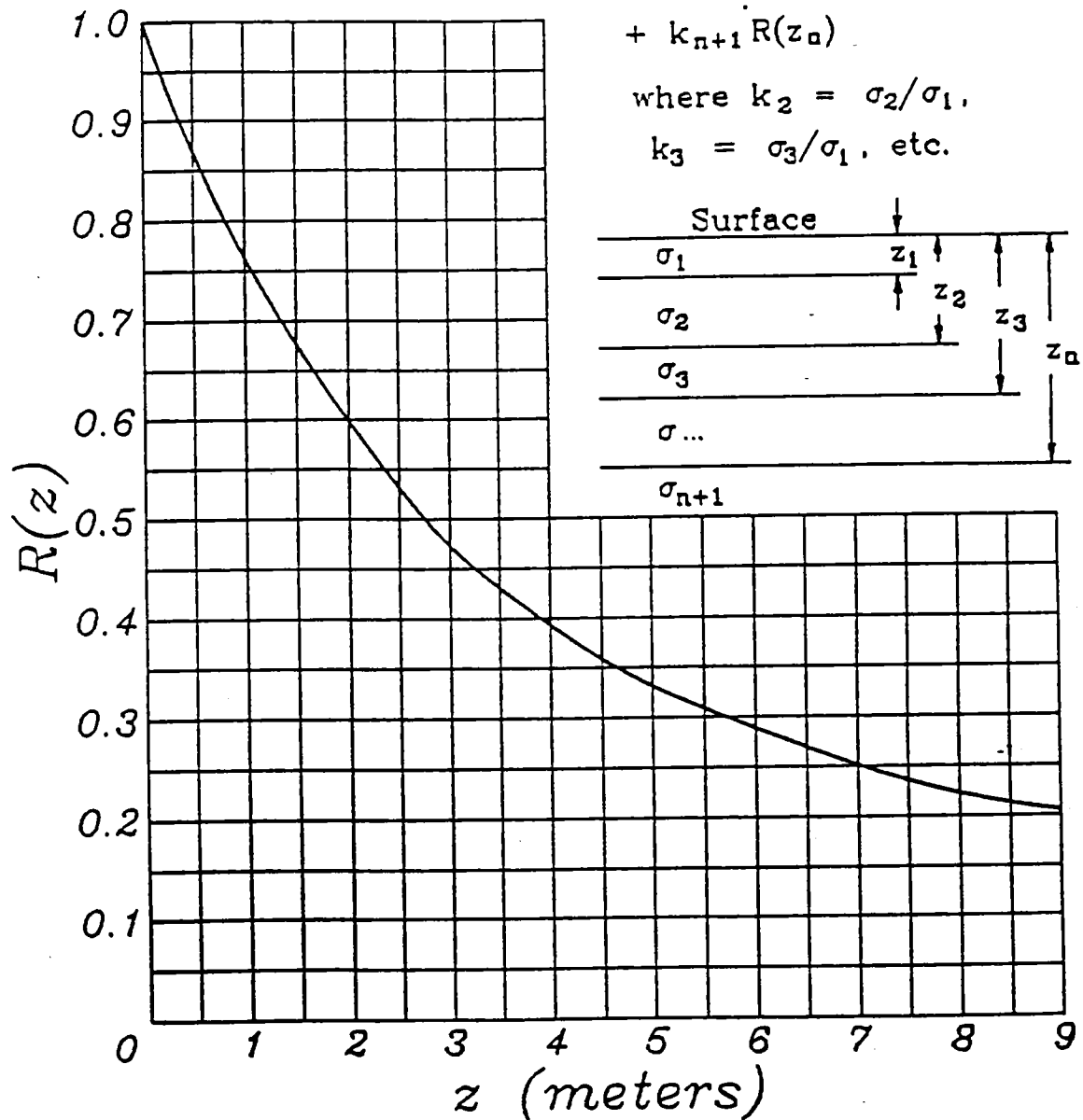


Figure 4: Multi-Layer Response Diagram



## 5.2 Multi-Layered Earth (cont'd)

The table accompanying the figure shows the calculations which yield the value of apparent conductivity at various thicknesses of the upper layer. Thus as we traverse such a structure we would find that the apparent conductivity fell from 32.6 millimhos per meter at a large distance from the buried river valley to 16.0 millimhos per meter at the centre of the valley.

Figure 6 illustrates a second situation where the objective is to locate bedrock highs within muskeg. This is again a two layer case and the table illustrates the calculations to determine the apparent conductivity. For this configuration, i.e. a conductor on top of an insulator and  $k_2$  a small quantity, the measured apparent conductivity becomes relatively independent of the actual value of the conductivity of the lower layer. For  $k_2 \ll 1$ , the apparent conductivity simply becomes a function of the thickness of the upper conductive layer.

Finally, a third example is given in Figure 7. In this case we wish to traverse a thickening gravel deposit; the maximum thickness is such that the instrument still responds to material below the deposit. This is an example of the situation of an insulator sandwiched between two conductors and is inevitably the most difficult geometry for electromagnetic systems to detect, as evidenced by the tabulated values of apparent conductivity. Even at a thickness of five meters (station D) there is still significant response from the till beneath the deposit and this response tends to keep the apparent conductivity high.

The three examples show how to calculate the response of the EM31 over a variety of geological environments.

## 5.2 Multi-Layered Earth (cont'd)

Since the instrument operates at a fixed intercoil spacing it is not possible to completely "sound" or evaluate differing conductivity layers with depth. Section 5.3 will show how to further resolve the two-layer case, however, it is always useful to be able to calculate the apparent conductivity which would arise from a given multi-layer model to see whether that model fits the measured data.

Figure 8 shows the apparent conductivity over the two limiting cases of a two layer geometry where the conductivity contrast is very large. In Figure 8A the upper layer is assumed to be very resistive and the figure shows the apparent conductivity with respect to the lower layer conductivity (assumed known) as a function of the depth below the surface of the lower layer, for values of  $k$  of ten and infinity. Thus for large  $k$  the figure permits the operator to quickly convert the measured values of apparent conductivity to depth, and to estimate the error if the conductivity contrast is not infinite.

Figure 8B performs the same task for small values of conductivity contrast. It should be noted that Figure 8B plots the apparent conductivity with respect to the upper layer conductivity.

It is stated in the data sheet that the effective depth of penetration of the EM31 is approximately six meters. Justification for this claim is shown in Figure 8 where it is seen that for either a resistive ( $k = \infty$ ) or conductive ( $k = 0$ ) upper layer the apparent conductivity is still satisfactorily sensitive to changes in the upper layer thickness at six meters. The limitation in resolving further changes in thickness is imposed by probable variations in the conductivity of either layer.

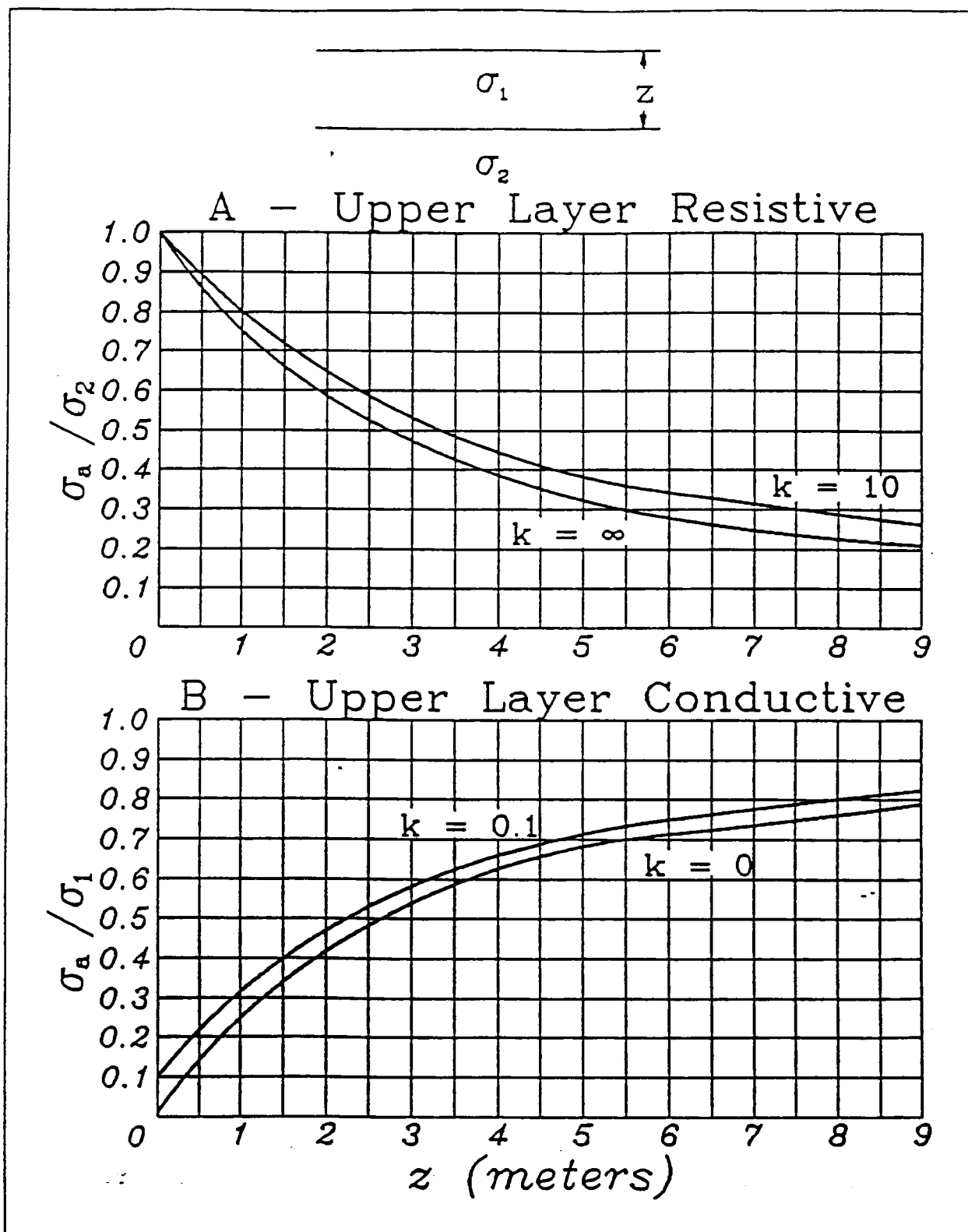


Figure 8: Response vs. Upper Layer Thickness

### 5.3 Geometrical Sounding of Two Layered Earth

It is possible with the EM31 to determine whether the conductivity increases or decreases with depth by laying the instrument on the ground, noting the reading, and then placing the instrument on its side so that the meter face is vertical and again noting the instrument reading. The reason for this is that when the instrument is on its side the new transmitter and receiver coil orientation with respect to the earth causes the effective depth of penetration of the instrument to be essentially halved. It should be noted that in this configuration the current flow does not exhibit the circular symmetry shown in Figure 1. Thus let  $\sigma_a$  be the apparent conductivity indicated by the instrument on the ground in its normal operating position and let  $\sigma_a'$  be the apparent conductivity indicated when the instrument is lying on its side. If  $\sigma_a$  is greater than  $\sigma_a'$  we know that the conductivity is increasing with depth and vice versa. The ability of the EM31 to indicate whether the conductivity is increasing or decreasing with depth is often of considerable diagnostic value.

It will be observed from the above that it is now possible to obtain two measured quantities at each measurement station. In the event that the earth consists only of two layers, there are three unknown quantities i.e. the conductivity of the upper and lower layer and the thickness of the upper layer. If one of these is known it is possible, using the technique described above, to determine the other two. More importantly, when there is a large conductivity contrast so that the conductivity of either the upper or lower layer can be ignored with respect to the other layer then it is possible to completely resolve the two layered earth. An example of the importance of this can be seen in Figure 8

### 5.3 Geometrical Sounding of Two Layered Earth (cont'd)

which gives the instrumental response as a function of upper layer thickness' for either a resistive or conductive upper layer. In order to use these graphs it is necessary to know the conductivity of the lower or upper layer respectively, since both graphs are normalized with respect to these quantities. An inaccurate knowledge of  $\sigma_2$  in the case of a resistive upper layer or  $\sigma_1$  in the case of a conductive upper layer can result in a substantial error in the calculated thickness of the upper layer. Any technique which allows us to determine the conductivity of the more conductive layer is of considerable importance since by definition the EM31 is most useful when one layer presents a significant conductivity contrast with respect to the other.

Figure 9 shows a multi-layer response diagram  $R(Z)$ , completely analogous to Figure 4 but with the instrument now laying on the ground. Figure 10, which presents the function  $R'(Z)$  as a function of depth is the same function as Figure 9 but now with the instrument rotated on its side so that the meter face is vertical. It will be noted from Figure 9 that with the instrument on the ground in its normal operating configuration the total contribution from all ground in excess of a depth of five meters is 34% whereas Figure 10 shows that with the instrument lying on its side the ground in excess of five meters causes a total contribution of only 17.5% of the total response. This is the justification for stating earlier that the instrument has effectively one half the depth penetration when lying on its side. Figure 9 also contains a plot of the ratio  $R'/R$  and Figure 10 a plot of the ratio  $(1-R')/(1-R)$ , both as a function of depth.

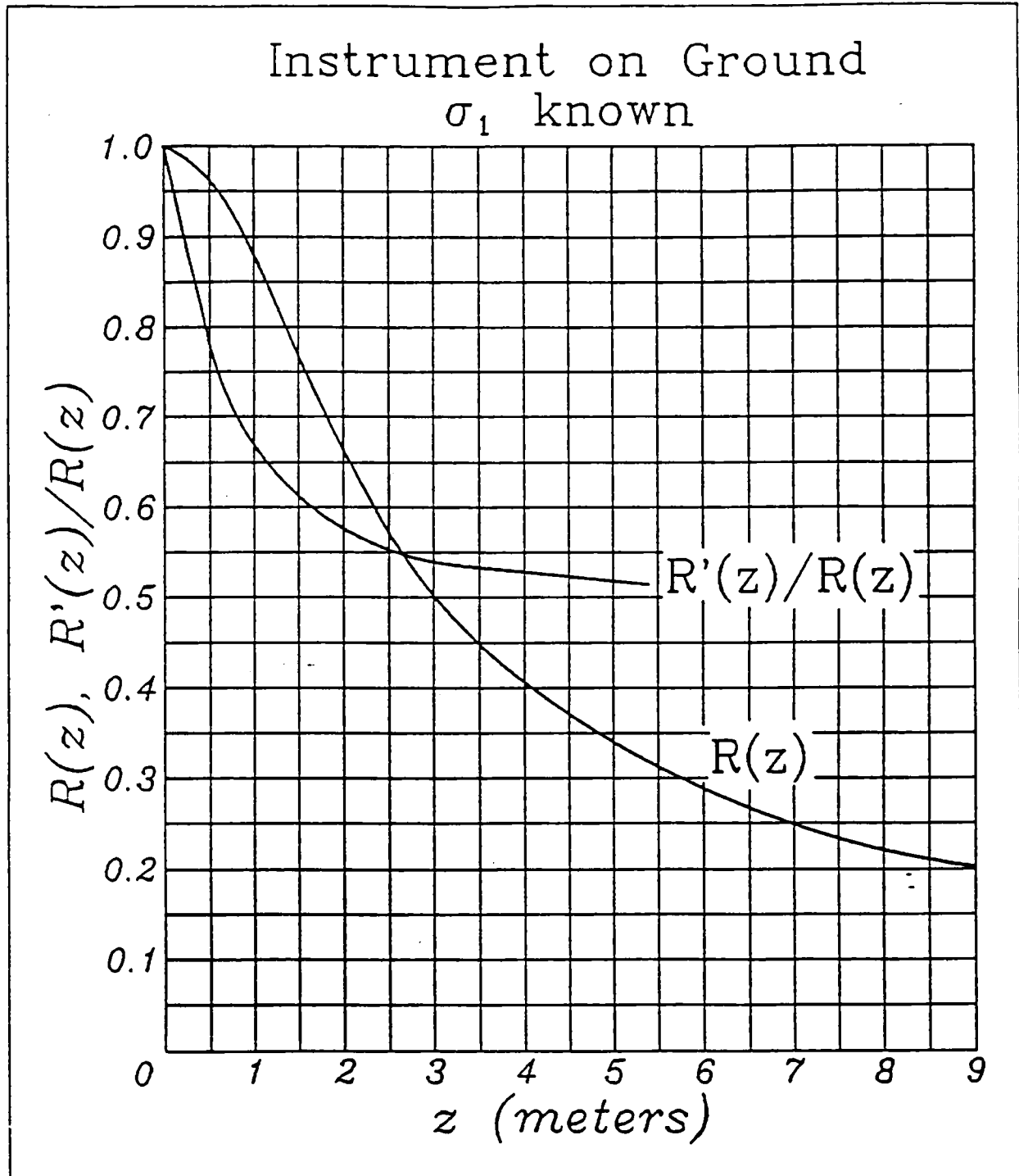


Figure 9: Two Layer Response, Part 1

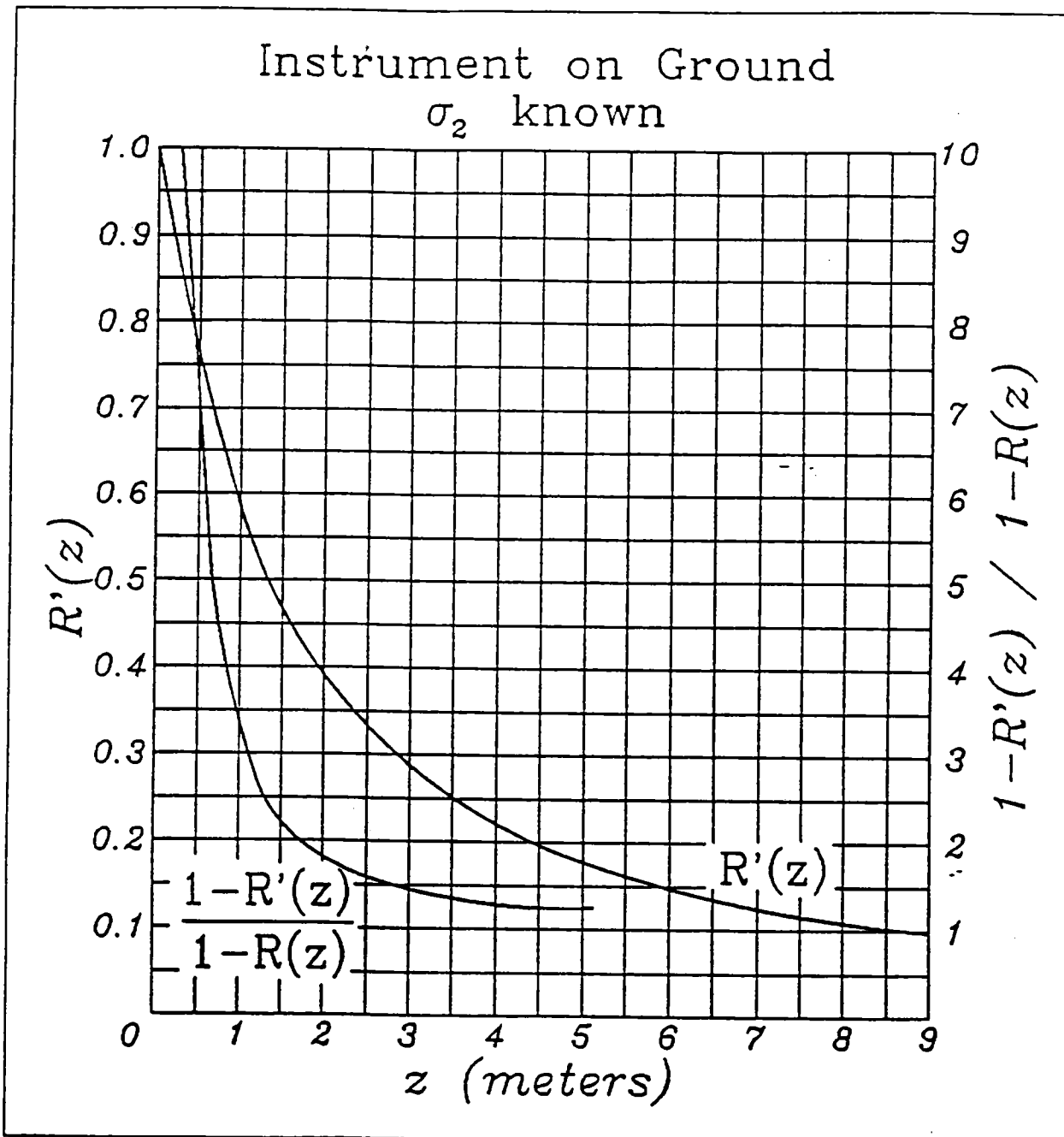


Figure 10: Two Layer Response, Part 2

### 5.3 Geometrical Sounding of Two Layered Earth (cont'd)

Case 1.  $\sigma_1$  and  $\sigma_2$  comparable and  $\sigma_1$  known. It is shown in Appendix 1 that for this case

$$\frac{R'(Z)}{R(Z)} = \frac{\frac{\sigma'_2}{\sigma_1} - 1}{\frac{\sigma_2}{\sigma_1} - 1}, \quad \sigma_2 = \frac{\sigma_2 - \sigma_1 + R\sigma_1}{R} = \frac{\sigma'_2 - \sigma_1 + R'\sigma_1}{R'}$$

thus given  $\sigma'_2$ ,  $\sigma_2$ , and  $\sigma_1$ ,  $R'/R$  is calculated; Figure 9 then gives the thickness of the upper layer as a function of  $R'/R$ ; with this thickness Figure 9 or 10 is used to determine  $R$  or  $R'$  and the second equation given above is used to determine  $\sigma_2$  thus fully resolving the two layer case.

Case 2.  $\sigma_1$  and  $\sigma_2$  comparable and  $\sigma_2$  known. In this case Appendix 1 shows that

$$\frac{1 - R'(Z)}{1 - R(Z)} = \frac{\frac{\sigma'_1}{\sigma_2} - 1}{\frac{\sigma_1}{\sigma_2} - 1}, \quad \sigma_1 = \frac{\sigma_1 - \sigma_2 R}{1 - R} = \frac{\sigma'_1 - \sigma_2 R'}{1 - R'}$$

Knowing  $\sigma'_1$ ,  $\sigma_1$ , and  $\sigma_2$ ,  $(1-R')/(1-R)$  is calculated; Figure 10 gives the thickness and given the thickness Figure 9 or 10 gives  $R$  or  $R'$  so that the second equation given above is used to calculate  $\sigma_1$ .

### 5.3 Geometrical Sounding of Two Layered Earth (cont'd)

Case 3. Upper layer resistive.  $\sigma_1$  much less than  $\sigma_2$ . In this case Appendix 1 shows that

$$\frac{R'(Z)}{R(Z)} = \frac{\sigma_a'}{\sigma_a}, \quad \sigma_2 = \frac{\sigma_a}{R} = \frac{\sigma_a'}{R'}$$

and the same procedure as for Case 1 above is used to determine the thickness of the upper layer and the conductivity of the lower layer.

Case 4. Upper layer conductive.  $\sigma_1$  much greater than  $\sigma_2$ . Again Appendix 1 shows that

$$\frac{1 - R'(Z)}{1 - R(Z)} = \frac{\sigma_a'}{\sigma_a}, \quad \sigma_1 = \frac{\sigma_a}{1 - R} = \frac{\sigma_a'}{1 - R'}$$

and the calculations for Case 2 yield the thickness and the conductivity of the upper layer.

To illustrate the above let it be assumed that the upper layer is known to be 10 millimhos per meter and the EM31 indicates 3.8 millimhos per meter when laying on the ground in its normal configuration and 6.5 millimhos per meter when lying on its side. Figure 3, which also gives the correction factor to use when the instrument is lying on its side, shows that no correction is necessary.

### 5.3 Geometrical Sounding of Two Layered Earth (cont'd)

Since the instrument has been calibrated to be operated at one meter above the ground both of these numbers must be multiplied by .88 since the instrument is being used on the ground. This results in  $\sigma_a = 3.3$  millimhos per meter and  $\sigma_a' = 5.7$  millimhos per meter. Then

$$\frac{R'(Z)}{R(Z)} = \frac{\frac{\sigma_a'}{\sigma_1} - 1}{\frac{\sigma_a}{\sigma_1} - 1} = \frac{\frac{5.7}{10} - 1}{\frac{3.3}{10} - 1} = 0.64$$

whereupon Figure 9 shows that the thickness of the upper layer is 1.25 meters and  $R(Z) = 0.825$  whereupon

$$\sigma_2 = \frac{\sigma_a - \sigma_1 + R\sigma_1}{R} = \frac{3.3 - 10 + 0.825 \times 10}{0.825} = 1.9$$

The technique for the other cases described above is exactly the same.

The calculations described above assume that the earth is known to be two-layered. It is possible to determine whether this is true by measuring the apparent conductivity with the EM31 elevated to various heights above the ground and comparing the results with a family of curves given in Appendix II. If the measured variation of apparent conductivity with height matches one of the curves, one can immediately calculate the conductivity of both layers and the thickness of the upper layer, as described therein.

## 6.0 CASE HISTORIES: ELECTROMAGNETIC NON-CONTACTING GROUND CONDUCTIVITY MAPPING

### 6.1 Introduction

This short note gives some illustrative examples of surveys that have been carried out using electromagnetic techniques to measure terrain conductivity. The instruments employed were the Geonics Limited EM31 and a prototype version of the Geonics Limited EM34. Both instruments were calibrated to read terrain conductivity in millimhos per meter directly; however, in some of the case histories illustrated in this note the measurements have been converted to resistivity in ohm-meters.

Two features which often limit the usefulness of conventional ground resistivity surveys are their high cost and in some regions (granular material, frozen ground) difficulties associated with generating sufficient current in the ground. The use of inductive electromagnetic techniques avoids both problems since ground probes are not required. This allows measurement over any type of terrain and greatly reduces the time to perform a survey.

Basically the technique consists of energizing a small coil at an audio frequency and measuring the resultant total magnetic field from this coil and the ground with another coil a fixed distance away. Theoretical studies show that, if the intercoil spacing is maintained at a small fraction of the electrical skin depth in the ground, all of the information about the ground conductivity is in the quadrature-phase response. Furthermore, the quadrature-phase response is essentially linearly related to ground conductivity, thus permitting an instrument design in which the output is calibrated to read conductivity (or resistivity) directly. Also under these conditions, the

## 6.1 Introduction (cont'd)

the effective depth penetration of the system is determined by the intercoil spacing and is independent of skin depth and thus of ground conductivity. This feature greatly simplifies interpretation of survey results. In order to vary the depth to which the resistivity is sensed one simply varies the intercoil spacing in analogy with conventional resistivity surveys. Conversely each survey carried out at a fixed intercoil spacing is essentially analogous to a survey carried out with conventional resistivity equipment at a fixed interprobe spacing.

The Geonics EM31 is a one-man portable instrument designed for engineering geophysical applications down to depths of the order of six meters. The intercoil spacing is fixed at twelve feet (3.66 meters). The effective penetration referred to above is an average value; in those regions where a conductive medium is to be located beneath a resistive layer the penetration depth is substantially larger.

The EM34 is operated at 3 intercoil spacings viz 10, 20 and 40m, resulting in effective depth penetrations of the order of 7.5 to 60m (25 to 50 meters) depending on the intercoil spacing employed for the particular survey. Operation of the EM34 requires two men; however, measurements are still taken virtually as fast as the team walks.

Most of the case histories in the technical note have been taken with the EM31; however, in some cases data from EM34 surveys are presented in order to further elucidate the features of inductive electromagnetic terrain resistivity mapping.

## 6.2 Example A: Heart Lake, Ontario (EM31)

Measurement Interval: 100 feet over till,  
10 feet over sand/gravel

This survey line compares the results obtained with conventional resistivity equipment (Wenner array with "a" spacings of 1 foot and 20 feet) and the Geonics EM31. It is seen that over the till, where the resistivity is slowly varying, the agreement between the two techniques is excellent. In the region shown as "sand and interbedded gravel" there was a good deal of concretion which caused the resistivity to vary greatly over short distances and which accounts for the discrepancy between the two techniques. Over the till the EM31 was read continuously although the data was only recorded, with one exception, at every 100 feet. The exception occurred at station 7+50 where it was noted that a local resistivity high occurred; this was of course not observed on the Wenner array since measurements were taken only at every 100 feet.

## 6.3 Example B: Sunnybrook Park (EM31, EM34) Measurement Interval: 100 feet

This case history shows measurements made with both the EM31 and the EM34 and illustrates the effective depth penetration of the two systems. The second sheet shows the results of expanding Wenner spreads at station 4+00 and 12+00. At station 4+00 we would expect the EM31 to read approximately 9.8 ohm-meters and the EM34 50 to 60 ohm-meters, which is the case. At station 12+00 the resistivity increases with depth and thus the EM31 should read a relatively low value and the EM34 a higher value which increases with intercoil spacing. This is indeed the case.

6.4 Example C: Cavendish Test Site (EM31)  
Measurement Interval: 50 feet

This survey, which was carried out over line C to establish the overburden resistivity shows that with the exception of the swamp area the overburden is extremely resistive. The value of resistivity obtained over the swamp is in good agreement with that from other measurements. The example also illustrates the performance of the instrument over Zones A & B, both of which are small highly conductive mineralized zones and cause the instrument to read off scale.

6.5 Example D: Lake Scugog (EM31)  
Measurement Interval: 50 feet

This survey illustrates the extremely high resolution achievable with the EM31 or the EM34 systems since neither technique requires electrical contact with the ground. Resolution in conductivity of the order of 3% or 4% is easily achieved and completely repeatable as long as the terrain remains unchanged. The example also illustrates the speed with which a survey can be carried out. In this particular case 1.9 line miles of survey was performed in seventy minutes with a station interval of 50 feet. Furthermore since the measurements were actually taken continuously any unusual activity in the resistivity between stations would have been recorded.

6.6 Example E:      Cooksville/Mississauga, Ontario (EM31)  
Measurement Interval: 25 feet

This example illustrates a survey carried out with the EM31 to search for a buried river channel. The channel, which is filled with glacial till, has been cut into the Dundas shale which, as seen from the example, has a resistivity of the order of 25 to 30 ohm-meters. The total time to plot out the profiles shown in the figure was approximately 1½ hours, with a measurement interval of 25 feet. A shortcoming of the technique is seen on line 5, where a region was encountered which was so conductive that it was not possible to take readings.

The second sheet illustrates the application of the two layer curves to interpret the survey results in terms of depth.

6.7 Example F:      Discontinuous Permafrost (EM31)  
Measurement Interval: Variable

These two examples were taken in Northern Canada and compared the results obtained with the EM31 with a medium frequency version of the Radiohm (Geonics EM16R) technique operating at 250 kHz. The data interval is fairly coarse, nevertheless there is good agreement between the two techniques, which is particularly interesting in view of the fact that the current distribution in the ground is totally different for the two systems. Furthermore the EM31 operates at a frequency of approximately 9.8 kHz whereas the MF radiohm operates at 250 kHz.

6.8 Example G:      Pre-glacial River Valley (EM31, EM34)  
Measurement Interval: 100 Feet

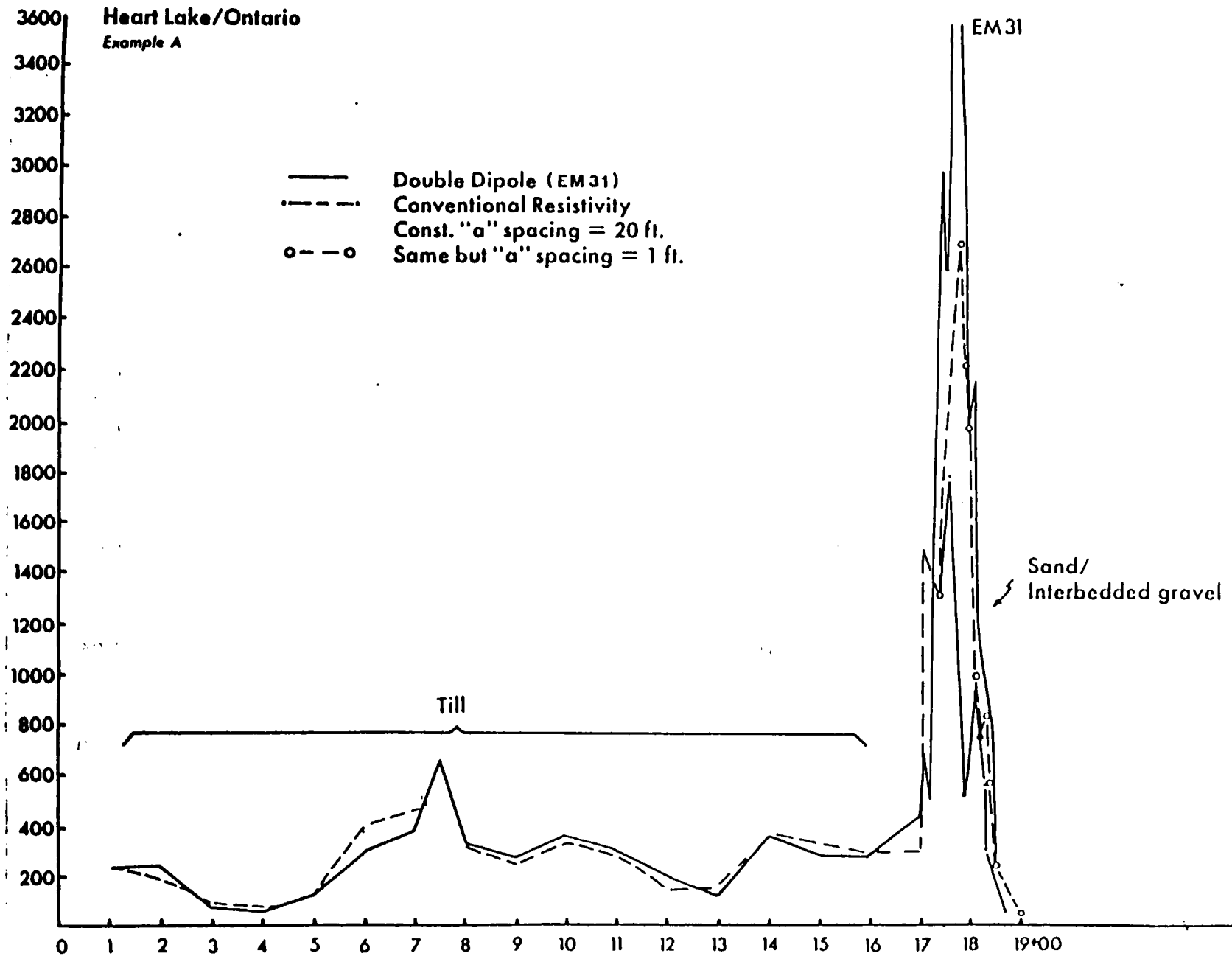
This survey was performed to outline a pre-glacial river valley whose existence had been suggested from water-well data. The survey was performed with the EM34 at a station interval of 100 feet and with intercoil spacings of both 50 and 100 feet. (An earlier model of the EM34 made use of 50 and 100 foot intercoil spacings. These spacings are not available with the current EM34 model). At either spacing the time required to complete the 8400 foot survey line was 1.5 hours. The same line was subsequently surveyed with the EM31.

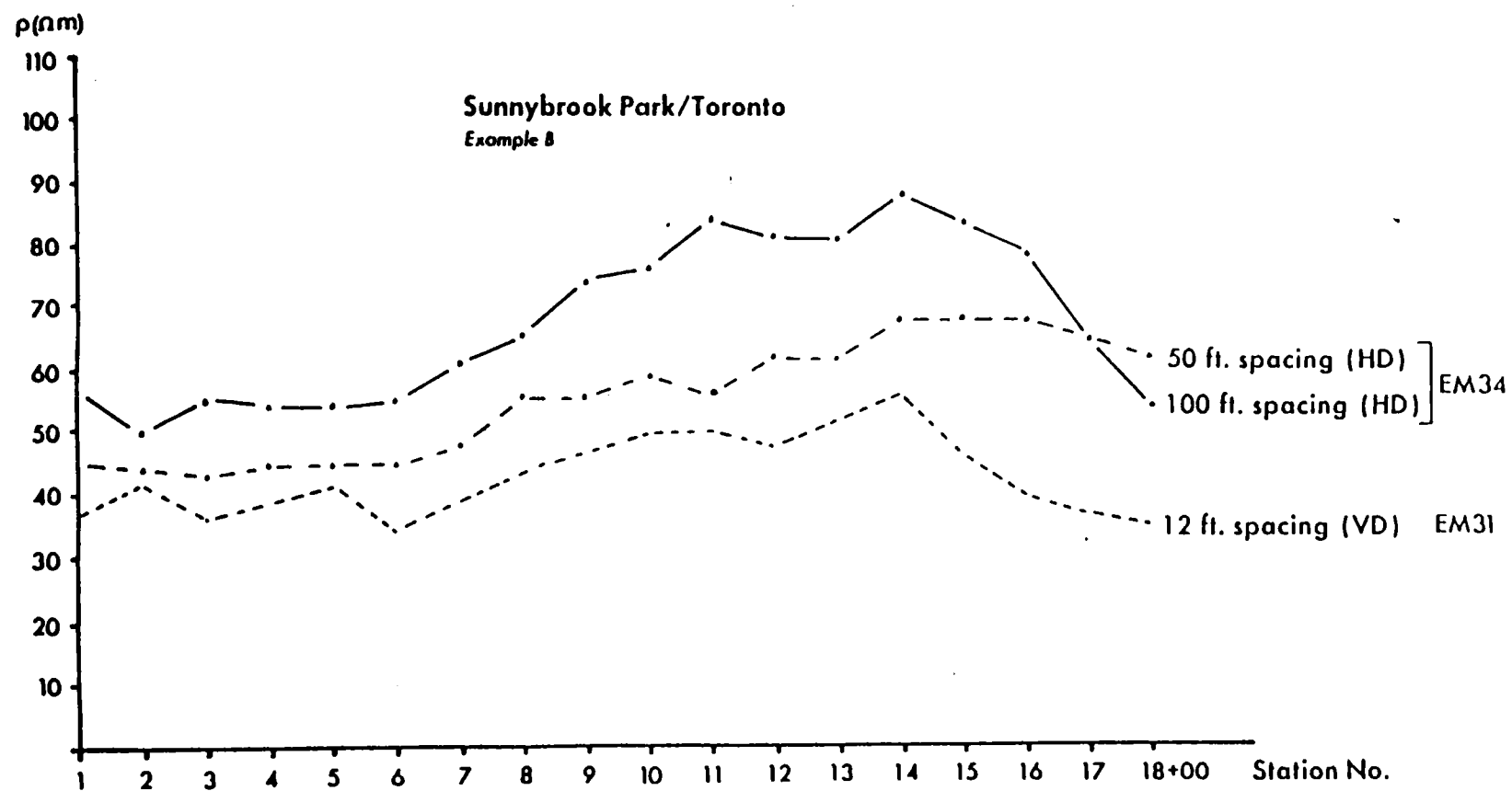
Typical bedrock conductivity in the area is approximately 32 millimhos per meter, whereas an average value for the conductivity of the infilling glacial till is of the order of 8 to 12 millimhos per meter. Thus the EM34 at either intercoil spacing yields approximately 30 to 34 millimhos per meter at the valley edges where the overburden is thin and 12 to 24 millimhos per meter at the valley centre. The EM31 yields values of 14 to 18 millimhos per meter at the valley edges (slightly affected by the presence of bedrock) and approximately 10 millimhos per meter at the valley centre. The interpreted depth of the valley, based on the model shown in the figure, is approximately 120 feet which is in reasonable agreement with the water-well data value of 150 feet, bearing in mind that the three sets of data show that a two layer model is an over simplification.

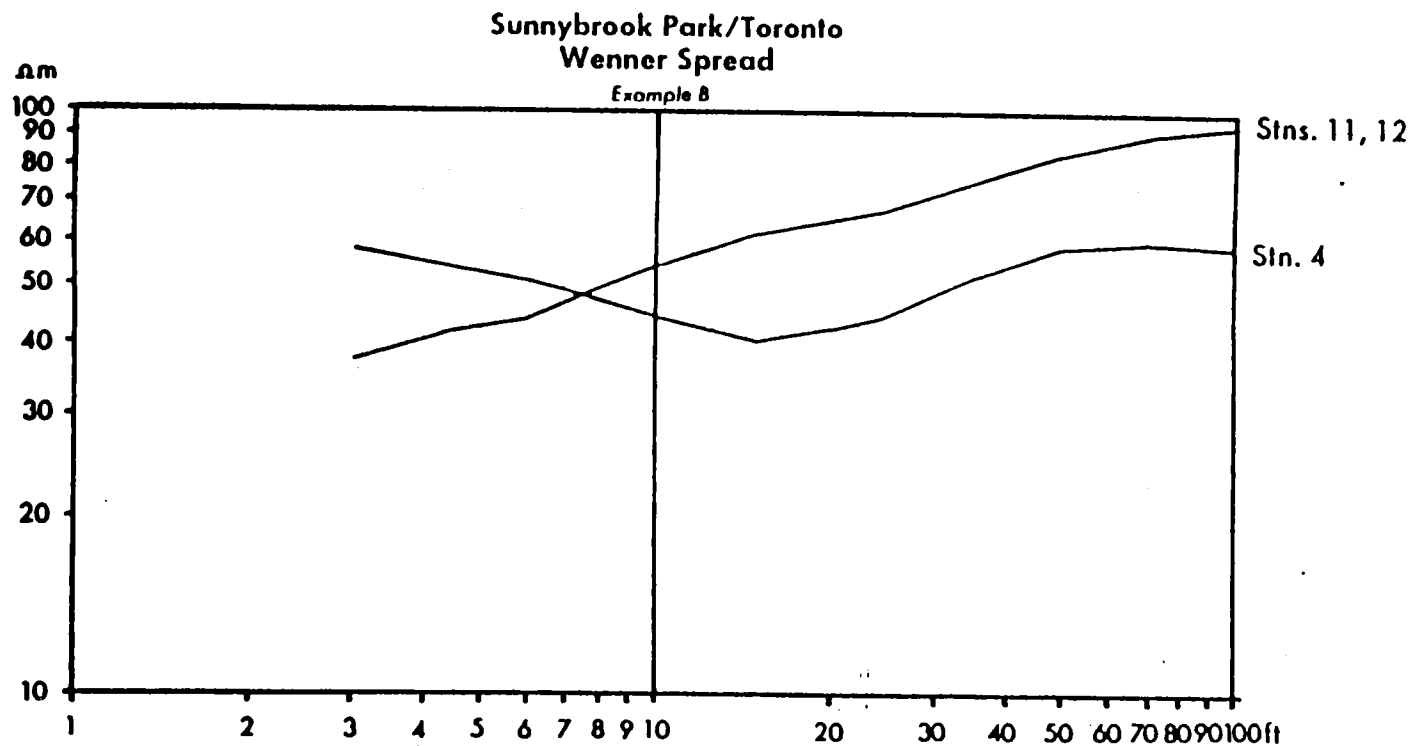
The conductivity high which occurs between station 32 and 38 results from a very large pile of waste furnace ash lying on the surface.

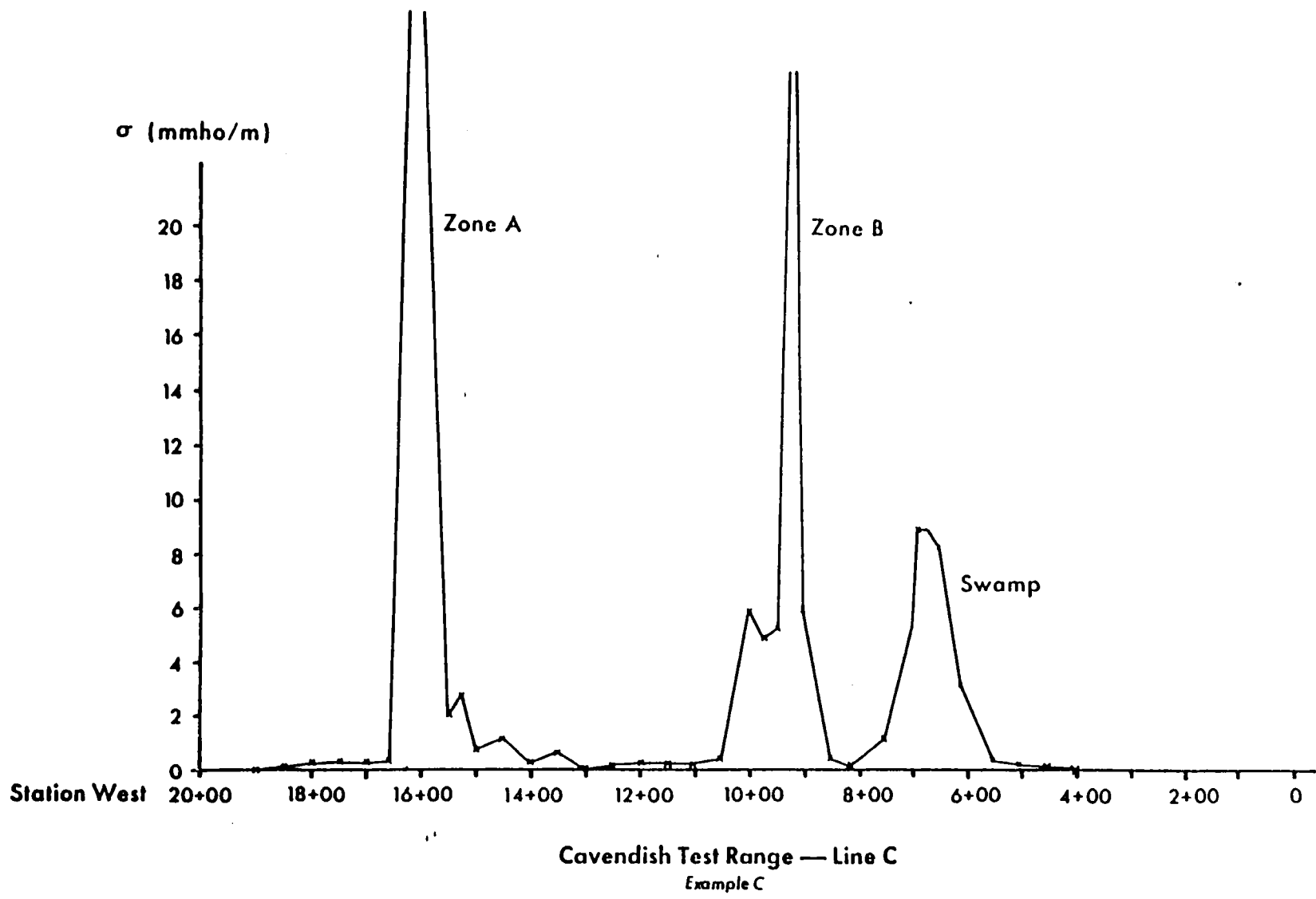
$\rho(\Omega m)$

**Heart Lake/Ontario**  
*Example A*



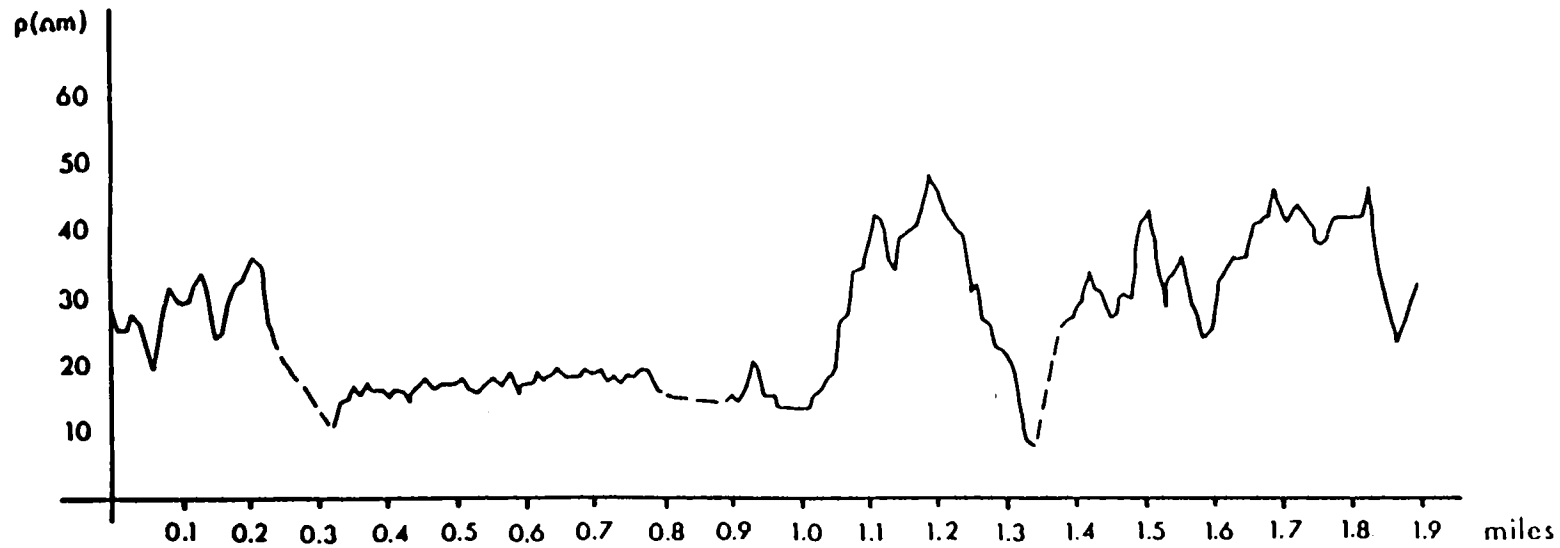


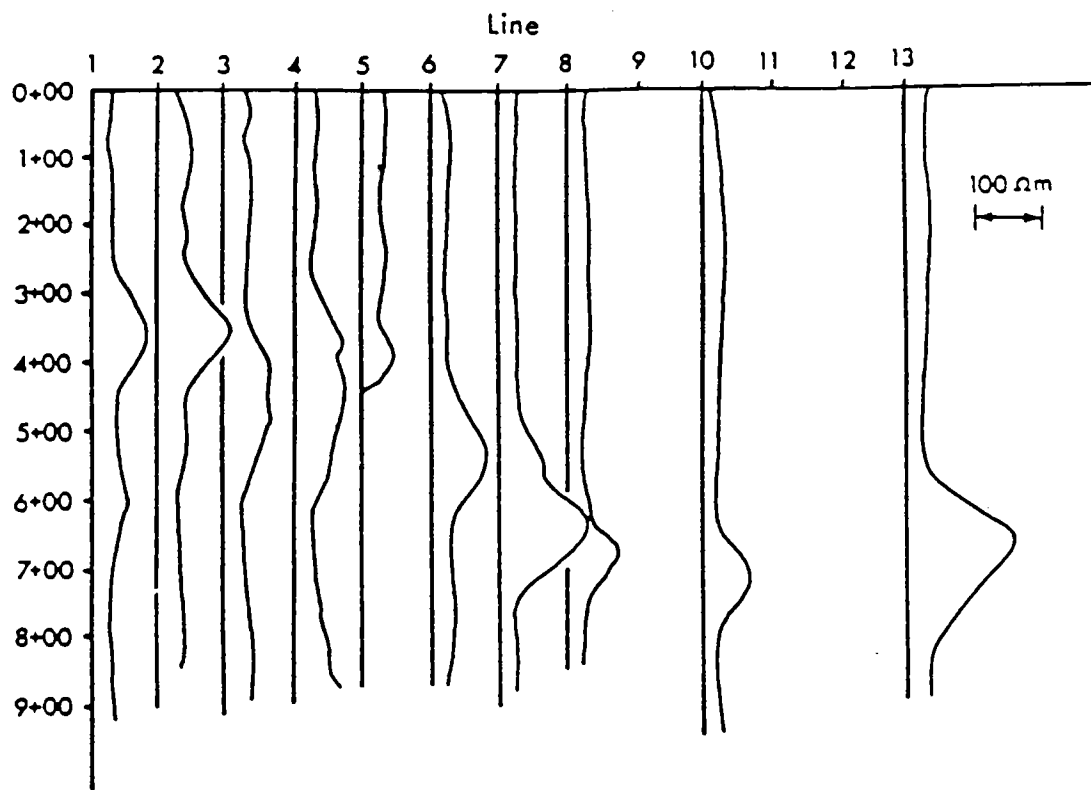




**Lake Scugog/East Causeway Example D**

- Note** (1) Station interval = 0.01 mile  
(2) Survey duration = 70 minutes  
(3) Total no. of stations = 190  
(4) 2.7 stations per minute



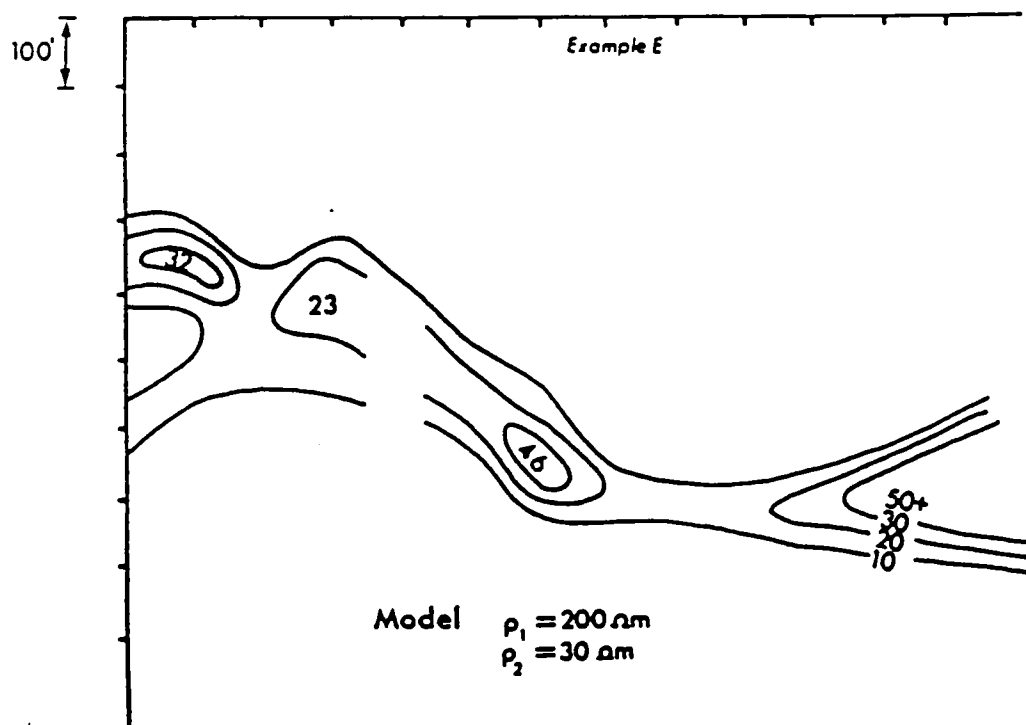


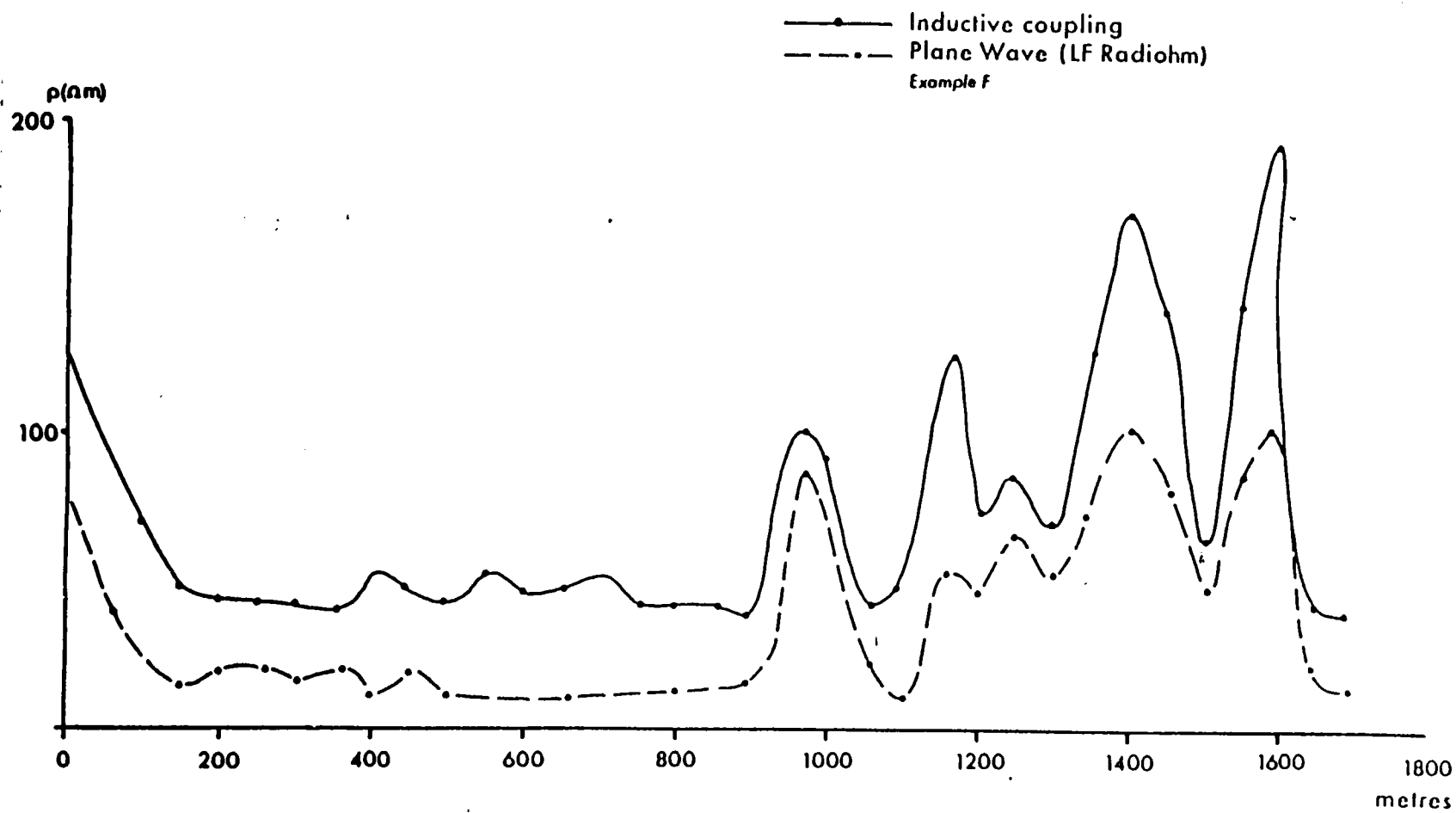
Cooksville/Ontario

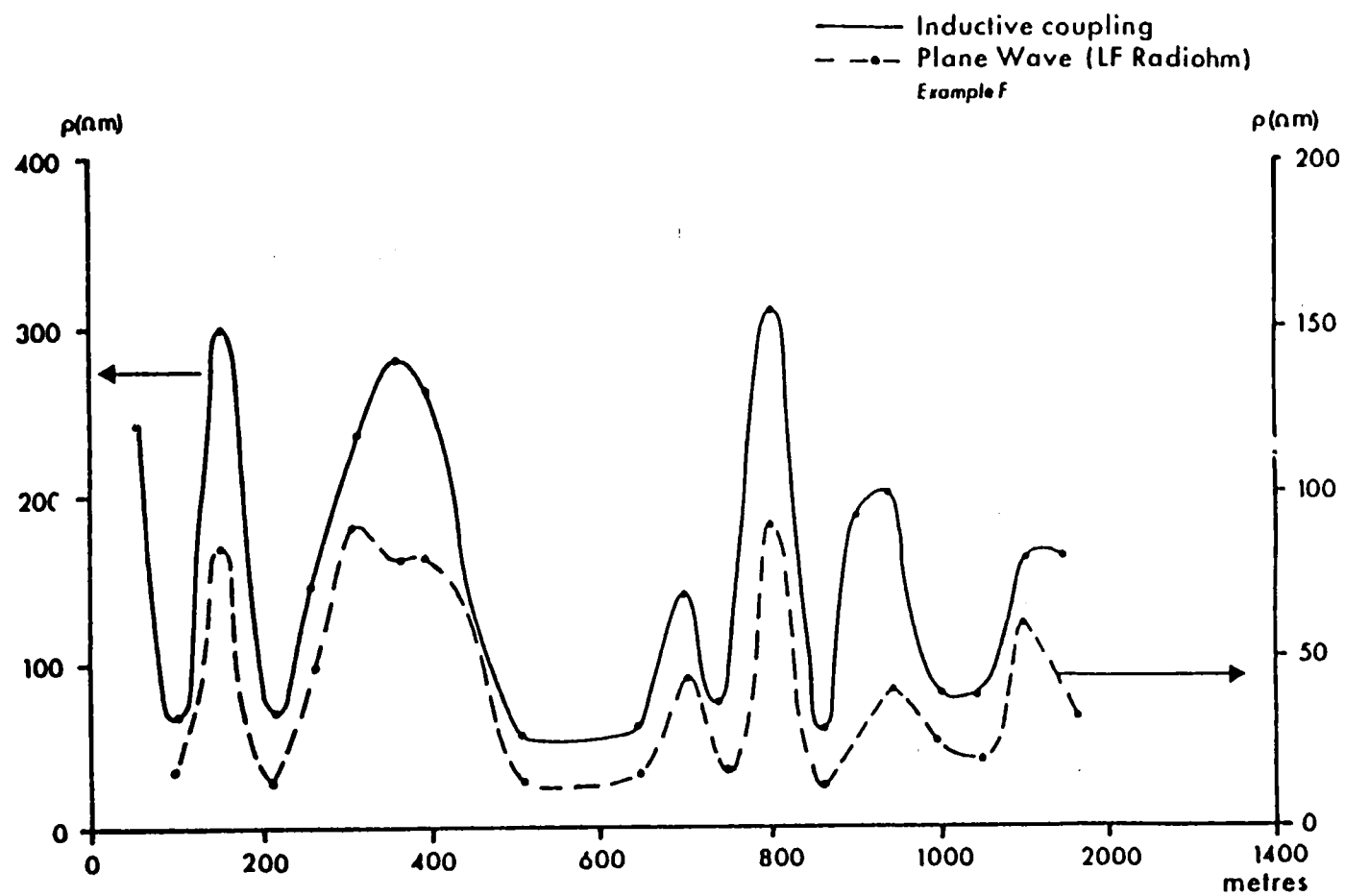
Example E

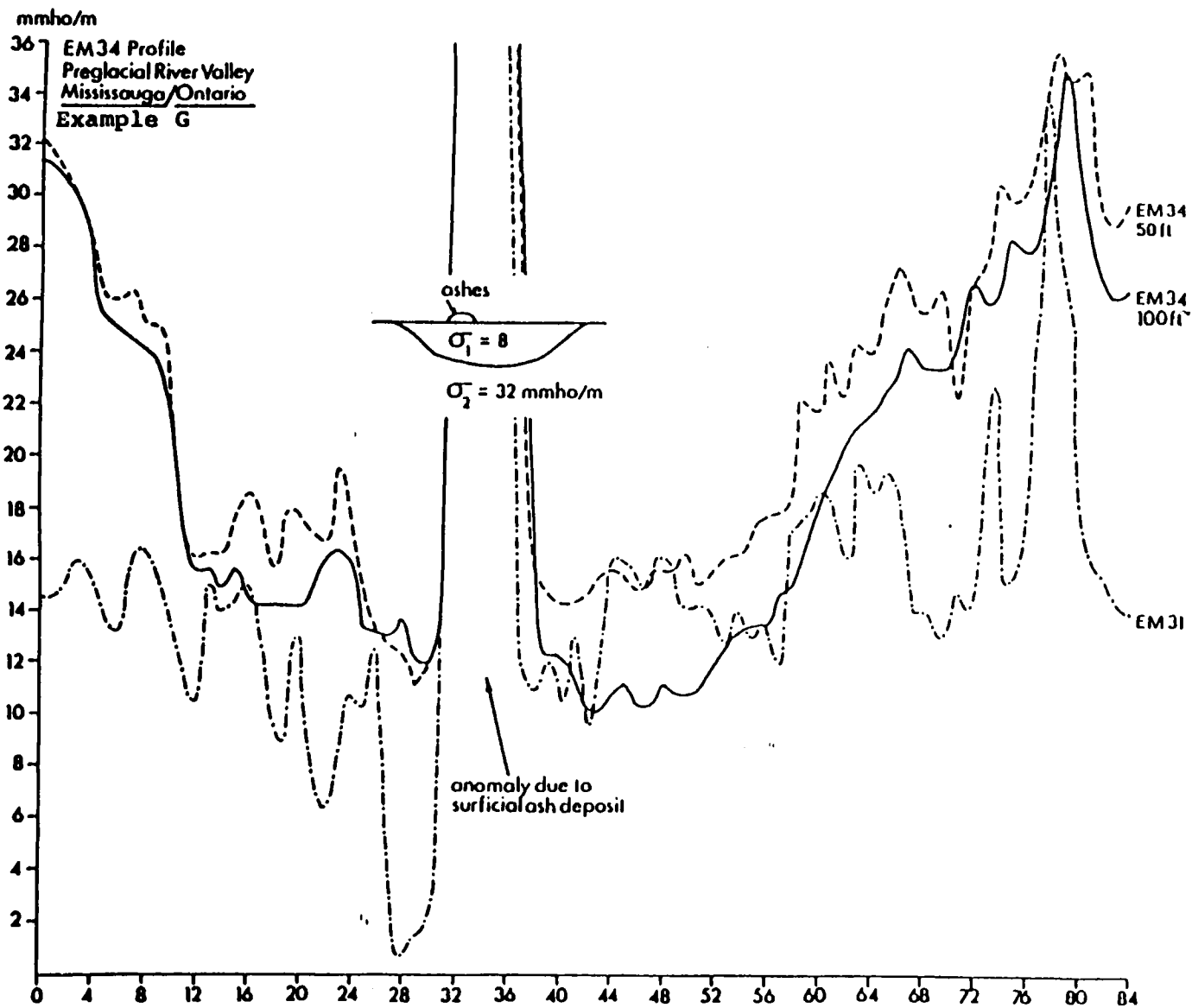
and

Contoured Depth









# APPENDIX I - Formulae for Geometrical Sounding of Two-Layered Earth

---

In the case of a two-layered earth the apparent conductivity is given by:

$$\frac{\sigma_a}{\sigma_1} = 1 - R + kR = R(k - 1) + 1 \quad (1)$$

with the instrument on the ground in its normal operating position, and

$$\frac{\sigma_a'}{\sigma_1} = 1 - R' + kR' = R'(k - 1) + 1 \quad (2)$$

with the instrument on the ground on its side.  
Case 1. Therefore

$$\frac{R'}{R} = \frac{\frac{\sigma_a'}{\sigma_1} - 1}{\frac{\sigma_a}{\sigma_1} - 1} \quad (3)$$

and from the first and/or second equations,  
with  $k = \sigma_2 / \sigma_1$

## APPENDIX I - (cont'd)

$$\sigma_2 = \frac{\sigma_a - \sigma_1 + R\sigma_1}{R} = \frac{\sigma_a' - \sigma_1 + R'\sigma_1}{R'} \quad (4)$$

Case 2. When the conductivity of the lower layer is known, from equations (1) and (2)

$$\sigma_a' = \sigma_1 - R'\sigma_1 + R'\sigma_2 \quad (5)$$

$$\sigma_a = \sigma_1 - R\sigma_1 + R\sigma_2 \quad (6)$$

$$\sigma_a' - \sigma_2 = \sigma_1 - R'\sigma_1 + R'\sigma_2 - \sigma_2 \quad (7)$$

$$= (1 - R')(\sigma_1 - \sigma_2) \quad (8)$$

$$\sigma_a - \sigma_2 = (1 - R)(\sigma_1 - \sigma_2) \quad (9)$$

$$\frac{1 - R'}{1 - R} = \frac{\frac{\sigma_a'}{\sigma_2} - 1}{\frac{\sigma_a}{\sigma_2} - 1} \quad (10)$$

## APPENDIX I - (cont'd)

$$\sigma_1 = \frac{\sigma_a - \sigma_2 R}{1 - R} = \frac{\sigma_a' - \sigma_2 R'}{1 - R'} \quad (11)$$

Case 3. When the upper layer is resistive and  $\sigma_2$  is much greater than  $\sigma_1$ , from equations (5) and (6)

$$\sigma_a = \sigma_2 R \quad (12)$$

$$\sigma_a' = \sigma_2 R' \quad (13)$$

$$\frac{\sigma_a'}{\sigma_2} = \frac{R'}{R} \quad (14)$$

and

$$\sigma_2 = \frac{\sigma_a}{R} = \frac{\sigma_a'}{R'} \quad (15)$$

Case 4. When the upper layer is conductive and  $\sigma_2$  is much less than  $\sigma_1$ , from equations (5) and (6)

$$\sigma_a = \sigma_1 (1 - R) \quad (16)$$

## APPENDIX I (cont'd)

$$\sigma_a' = \sigma_1(1 - R') \quad (17)$$

$$\frac{1-R'}{1-R} = \frac{\sigma_a'}{\sigma_a} \quad (18)$$

$$\sigma_1 = \frac{\sigma_a}{1 - R} = \frac{\sigma_a'}{1 - R'} \quad (19)$$

## APPENDIX II - Determination of Two-Layered Earth Geometry by Varying Instrument Height

The electrical conductivity of the earth often exhibits horizontal layering and it is possible with the EM31 to determine how closely this layering can be approximated by a two-layered earth geometry.

Suppose measurements made with the instrument on the ground have yielded different values of apparent conductivity when the instrument meter is (a) face-up (i.e. the instrument is in normal position), and (b) the instrument is lying on its side. As discussed in Section 5.3 had the value of apparent conductivity been the same in both positions we would know that the earth was homogeneous, but the fact that the values are different for the two positions shows that the electrical conductivity varies with depth. We would now like to know whether the earth is two-layered.

To determine this we make measurements of the apparent conductivity with the instrument at various heights above the ground, as measured by the distance between the ground and the nearest point of the white tube. It is suggested that measurements be made at increments at least as small as one-half meter, for example at 0, 0.5, 1, and 1.5 meters. Measurements made at smaller increments will yield greater accuracy, as will measurements made up to 2 meters height if possible. Measurements should be made both with the instrument in its normal position (meter face upright, i.e. vertical dipoles,) and with the instrument on its side (meter face vertical, horizontal dipoles) since it will be seen from the curves that the fall-off with height for these two

## APPENDIX II - (cont'd)

configurations is quite different and that this difference is therefore of considerable diagnostic value in determining the two-layered earth characteristic. It is important to make the measurements of height and apparent conductivity as accurately as possible.

The curves in the two figures show the variation of apparent conductivity (divided by upper layer conductivity) for instrument height varying from 0 to 2 meters and for five values of upper layer thickness viz 0.5, 1.0, 1.5, 2.0, and 3.0 meters. The relationship is shown for both vertical dipoles (meter face up, instrument in normal position) and horizontal dipoles (meter face vertical, instrument on its side) for various values of upper layer to lower layer conductivity contrast.

To use the curves one proceeds as follows:

- (1) Place a piece of semi-transparent paper over either one of the graphs and on it plot the measured values of apparent conductivity versus instrument height to the scale used on the figures. Also sketch in on the transparent paper at any point a horizontal or vertical line to insure that when the transparent paper is translated over the figures in step 2 it does not rotate.
- (2) Translate the transparent paper vertically and horizontally (i.e. without rotation) across the various plots shown on the figures to see whether the data points can be matched to one of the curves. In the event that no satisfactory match is achieved the earth cannot be represented by a two-layered case.

## APPENDIX II - (cont'd)

(3) If a satisfactory match can be achieved, the parameters of the two-layered earth are immediately calculated as follows: suppose that the measured values of apparent conductivity with height are

Height	0.0	0.5	1.0	1.5	2.0 meters
$\sigma_a$ (EM31 upright)	20.7	20.7	19.3	17.1	14.1 mmho/m
$\sigma'_a$ (EM31 on side)	26.0	19.0	14.3	11.2	9.0 mmho/m

Upon plotting these data values to the scale of the figures and translating them we see that best agreement is achieved for an upper layer thickness of 1.5 meters and a conductivity contrast  $k = 0.5$ . We further observe that the value of 20.7 millimhos per meter for  $\sigma_a$  (instrument up-right) corresponds to a value of  $\sigma_a/\sigma_1$  of 0.62.

$$\text{Since } \frac{\sigma_a}{\sigma_1} = 0.62 \quad \text{when } \sigma_a = 20.7$$

$$\therefore \sigma_1 = \frac{20.7}{0.62} = 33.4 \text{ mmho/m}$$

$$\text{Since } k = \frac{\sigma_2}{\sigma_1} = 0.5$$

$$\therefore \sigma_2 = 0.5 \times 33.4 = 16.7 \text{ mmho/m}$$

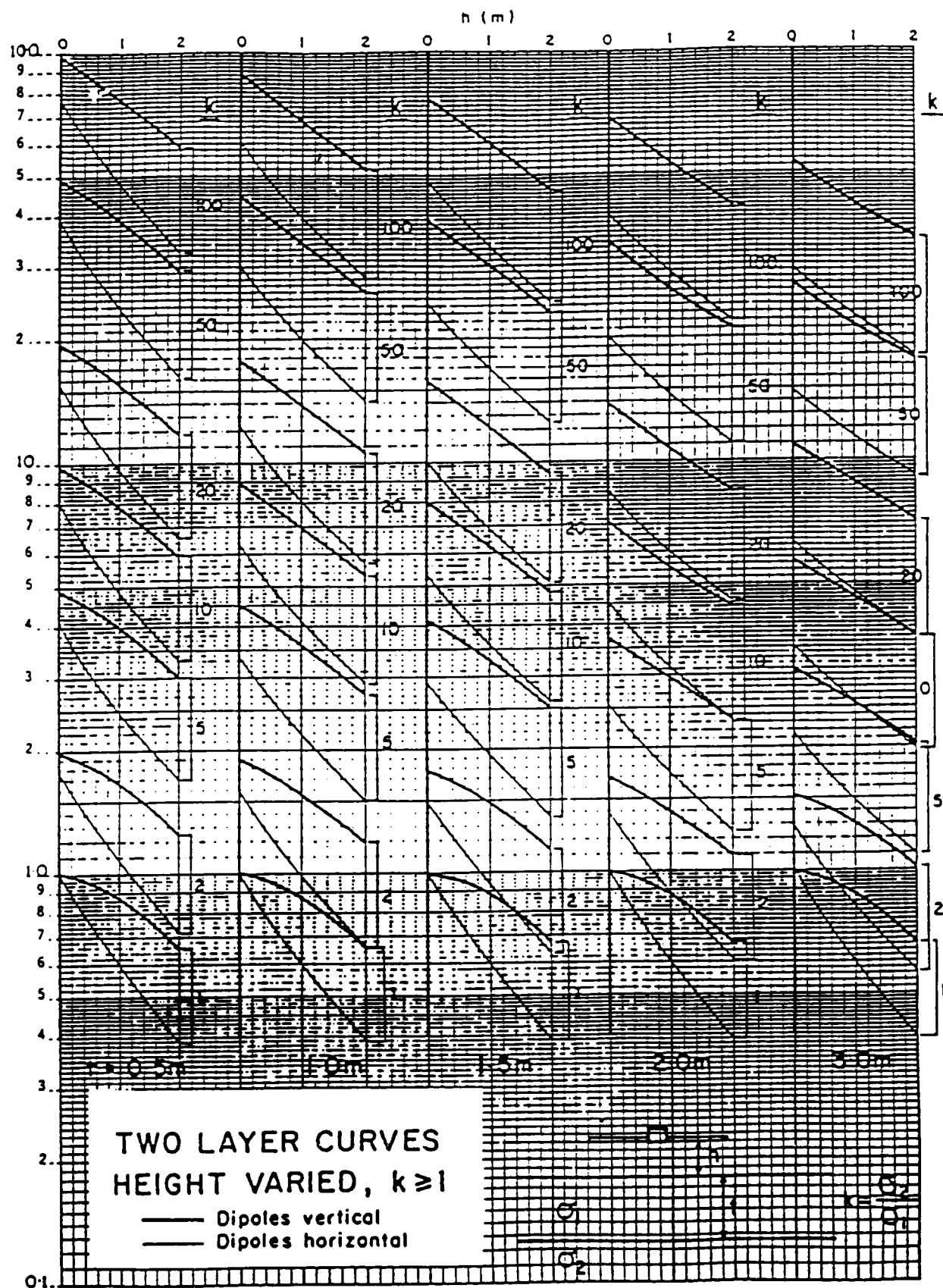
$$\text{and } t = 1.5\text{m from the figure.}$$

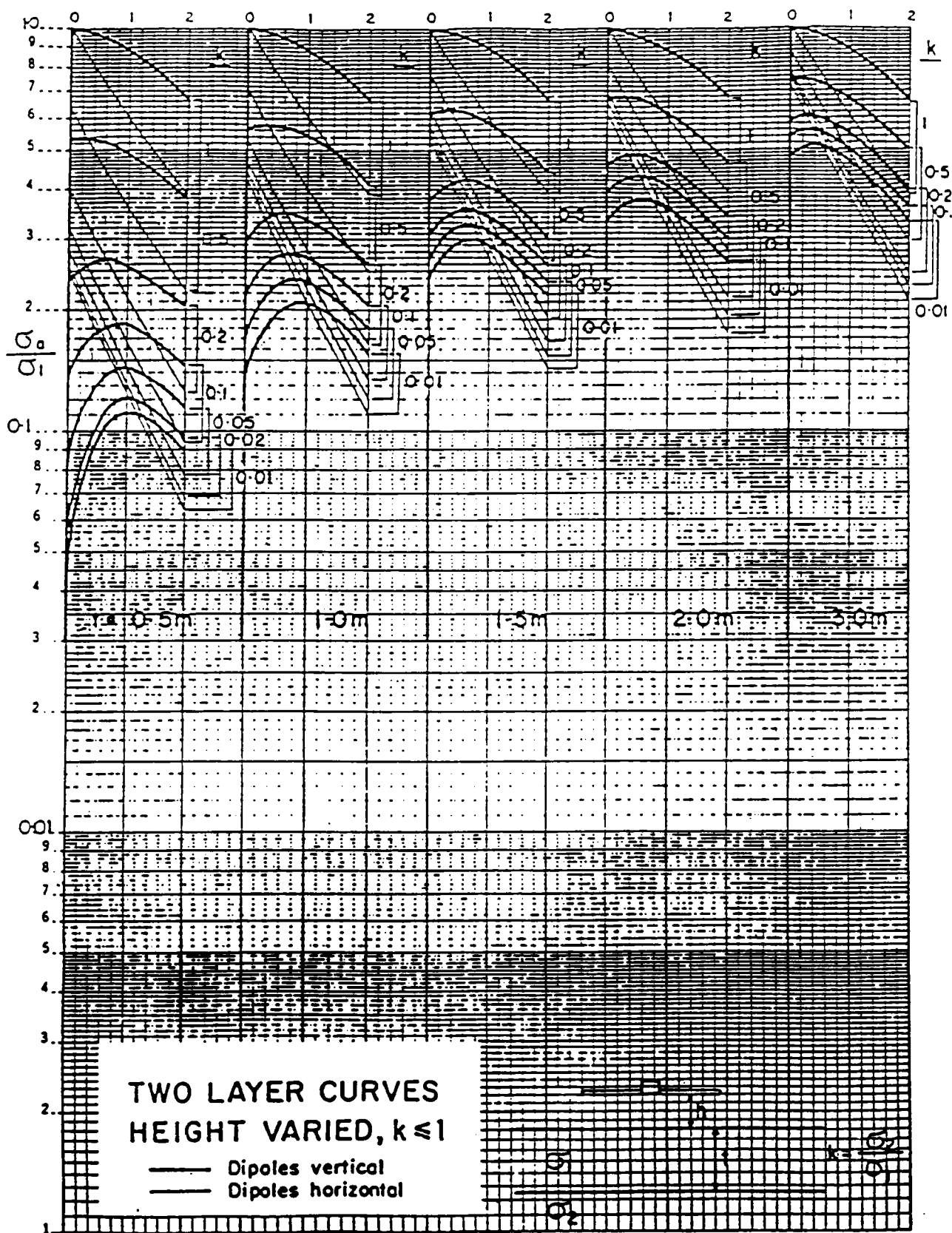
## APPENDIX II - (cont'd)

The two-layered earth is fully resolved.

It will be observed that in some regions on these two figures the resolution or differentiation between the various curves is not very great. For example if one examines the curves for  $t = 1.0$  meters, and  $k = 100, 50, \text{ or } 20$ , one sees that these curve pairs are almost identical. If the process described in step 3 is carried out for each of these conductivity contrasts the result of the calculations will show that the lower layer conductivity and the upper layer thickness are the same regardless of which of the three curve pairs are used, and that the only calculated parameter that will vary will be the upper layer conductivity which is very small. This is an example of the well-known property of electromagnetic systems to accurately give both the distance to a good conductor and the actual conductivity of the conductor but to poorly define the intervening resistive material. A problem in unambiguously matching the curves may also occur for larger values of upper layer thickness, where the thickness is sufficiently great to prevent accurate resolution of its value.

These features notwithstanding it will be found that these curves are useful in (a) deciding whether the ground resembles a two-layer case and if so (b) giving a reasonably accurate estimate of the electrical parameters.





# MICROTIP<sup>IS-3000</sup>

Hand Held Air Monitor/Photoionization Detector



**CLASS I, DIVISION 1  
GROUPS A, B, C, D T4(135°C)  
HAZARDOUS LOCATIONS**

Classified by Underwriters Laboratories Inc. only as  
to Intrinsic Safety for Use in Hazardous Locations

## User's Manual

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Part No. 395018

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**NOTICE**

THIS DEVICE IS CLASSIFIED FOR USE IN CLASS I, DIVISION 1, GROUPS A, B, C, D HAZARDOUS LOCATIONS, T4 (135°C) RATING.

It complies with Underwriters Laboratories Inc. UL 913 Standard for Intrinsically Safe Apparatus and Associated Apparatus for use in Class I, Division 1, Groups A, B, C, D Hazardous (Classified) Locations, Fourth Edition.

THIS DEVICE IS INTENDED FOR USE WITH FLAMMABLE CONCENTRATIONS OF GASES.

These Photovac accessories are also for use with the device in a hazardous location:

395002 Shoulder Strap	390022 9.5 eV Lamp
395007 Carrying Case	390024 11.7 eV Lamp
390006 3 Meter (9.8') Sample Line	390033 Calibration Kit

Do not use any other accessories with this device in a hazardous location.

Substitution of components may affect safety rating.

**CAUTION**

To reduce the risk of fire or injury to persons, read and follow these instructions:

1. All calibration, maintenance and servicing of this device, including battery charging, must be performed in a safe area away from hazardous locations.
2. For replacement battery pack use only Photovac Part No. 395023.
3. Do not dispose of the battery pack in a fire. The cell may explode. Check with local codes for possible special disposal instructions.
4. Do not open or mutilate the battery packs. Released electrolyte is corrosive and may cause damage to the eyes or skin. It may be toxic if swallowed.
5. Exercise care in handling battery packs in order not to short the terminals with conducting materials such as rings, bracelets and keys. The battery or conductor may overheat and cause burns.
6. Do not defeat proper polarity orientation between the battery pack and battery charger.
7. Charge the battery pack provided with or identified for use with this product only in accordance with the instructions and limitations specified in this manual.

## Chapter 1 Introduction

**Chapter 1 Introduction****1.1 UNPACKING**

Included with the instrument you will find the following standard accessories:

- User's Manual
- 120/230 Volt Battery Charger
- 17 cm (6.8") Sample Line
- 5 Spare Filter Cartridges
- Shoulder Strap
- Dust Cap Removal Key

Remove MicroTIP™ and accessories from the shipping box and examine them for any physical damage. Inform Photovac immediately if MicroTIP or the accessories are damaged.

Instruments being used outside the United States and Canada must have a new plug installed on the battery charger. See Appendix A.

**1.2 RECHARGING THE BATTERY**

Before beginning operation of MicroTIP, the battery pack must be charged.

**Note:** Do not remove, replace or charge the battery pack in a hazardous location.

Use only MicroTIP battery charger Photovac Part No 395016 for 110V or 395017 for 220V. Using an other MicroTIP battery charger will result in damage to the IS-3000 battery pack or charger.

1. Ensure MicroTIP is off by pressing the front of the power switch. See Figure 1.
2. Set the voltage selector switch on the bottom of the battery charger to the appropriate AC line voltage.
3. Press the release button on the bottom of MicroTIP and remove the battery pack by sliding it backwards. See Figure 1.

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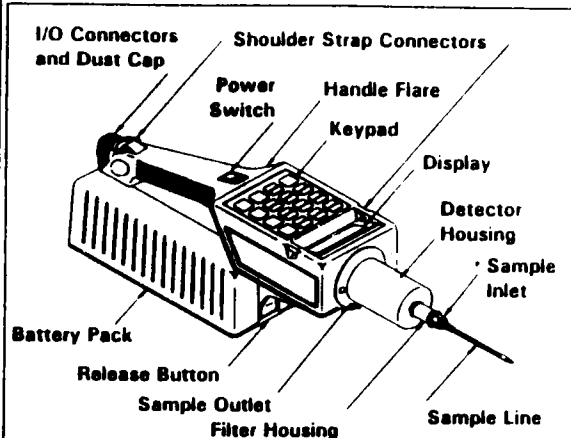
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#### WARNING

THIS EQUIPMENT GENERATES, USES AND CAN RADIATE RADIO FREQUENCY ENERGY AND IF NOT INSTALLED AND USED IN ACCORDANCE WITH THE INSTRUCTION MANUAL, MAY CAUSE INTERFERENCE TO RADIO COMMUNICATIONS. IT HAS BEEN TESTED AND FOUND TO COMPLY WITH THE LIMITS FOR DOC STANDARD C108.8 AND FOR A CLASS A COMPUTING DEVICE PURSUANT TO SUBPART J OF PART 15 OF FCC RULES, WHICH ARE DESIGNED TO PROVIDE REASONABLE PROTECTION AGAINST SUCH INTERFERENCE WHEN OPERATED IN A COMMERCIAL ENVIRONMENT. OPERATION OF THIS EQUIPMENT IN A RESIDENTIAL AREA IS LIKELY TO CAUSE INTERFERENCE IN WHICH CASE THE USER AT HIS OWN EXPENSE WILL BE REQUIRED TO TAKE WHATEVER MEASURES MAY BE REQUIRED TO CORRECT THE INTERFERENCE.

**Figure 1 MicroTIP Layout**

4. Plug the charger into the battery pack and then into an AC outlet and allow the battery pack to charge until the red LED on the battery charger flashes slowly. If the battery pack is fully discharged this will take about 8 hours.
5. After charging remove the charger, first from the wall outlet then from the battery pack, and slide the battery pack back onto MicroTIP.

The instrument is now fully charged and ready for use.

## Chapter 2 Operation

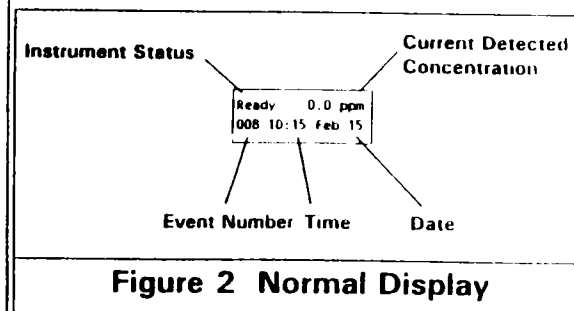
### 2.1 OVERVIEW

MicroTIP measures the concentration of airborne photoionizable gases and vapors and automatically displays and records these concentrations.

MicroTIP does not distinguish between individual pollutants. The reading displayed represents the total concentration of all photoionizable chemicals present in the sample.

Turn the instrument on by pressing the back of the power switch. The pump will start and the message "Warming up now, please wait" will be displayed. Within three minutes the following information will appear on the display: instrument status, current detected concentration, Event number (if the datalogger is on), time, and date.

Warming up now,  
please wait...

**Figure 2 Normal Display**

MicroTIP operates automatically. The user reads concentrations directly from MicroTIP's display. The display updates itself each half second.

The Minimum, Maximum, and Average concentrations measured in each 15-second period are automatically recorded in MicroTIP's datalogging memory if the datalogger is turned on. MicroTIP's memory holds 12 hours of concentration data.

Concentration data can be played back from memory on MicroTIP's display, sent to a printer in either tabular or graphical format or sent to a computer in tabular format.

## Chapter 2 Operation

## Chapter 2 Operation

Data are recorded by date, time, and by a sequential Event number. Data are played back by the user specifying a start and a stop Event number.

The keypad is used to set up and calibrate MicroTIP, and allows the user to manipulate the concentrations measured and recorded by MicroTIP in various ways. MicroTIP has 16 clearly labelled keys for direct numeric entry and for using MicroTIP's functions.

All information entered from the keypad and stored in MicroTIP's memory is retained when MicroTIP is switched off. The clock and calendar continue to operate and do not need to be reset the next time MicroTIP is used.

## 2.2 TUTORIAL SESSION

To assist the user in learning the key functions, MicroTIP has a built-in tutorial session which displays a two-line description of the function of each key. Pressing MicroTIP's TUTOR key begins a tutorial session and pressing the EXIT key after any key ends the session. While in the tutorial session, keypresses have no effect on MicroTIP's operation.

Press the TUTOR key and begin a tutorial session. Press each key and read the display. The tutorial display for each key is given in Table 1.

BATT	Shows battery V normally 6-8.5V	ALARM	Shows set-point for conc alarm
DISPLAY	Displays conc as graph or numeral	MAX	Displays highest conc measured
LIGHT	Shows intensity of detector lamp	SETUP	Sets date time & options for keys
AUDIO	Selects alarm or tone or no audio	EVENT	Sets options for recording data
PRINT	Prints table of recorded data	TUTOR	Press a key then read explanation

**Table 1 TUTOR Displays**

GRAPH	Prints graph of recorded data	CLEAR	Erases the last number pressed
PLAY	Replays recorded data on display	EXIT	Cancels key with no more changes
CAL	Calibrates with zero & span gas	ENTER	Confirms display then continues

**Table 1 - continued**

If there are no options to the function then the key acts immediately. If there are options, then the current option is displayed on the lower line. The user is prompted to display the other options by pressing the up arrow or down arrow key. Pressing ENTER confirms that the displayed option is correct. If the function requires numeric input then the current value is displayed on the lower line. The user can change it on the display by pressing the numeric keys. Pressing ENTER confirms that the displayed value is correct.

Some functions have multiple steps for options and/or numeric inputs. These are arranged so that the most frequently changed inputs are displayed first. Once the desired changes have been made the user can bypass the rest of the steps by pressing EXIT.

Each key function is described in more detail in the following sections. Leave MicroTIP on and try each key in turn.

## 2.3 DISPLAY

If a numerical display is shown, pressing DISPLAY will change it to a bar graph. If the bar graph is shown, pressing DISPLAY changes it to a numerical display. The bar graph range is selected with the SETUP key.

## 2.4 LIGHT

Pressing the LIGHT key displays the visible intensity of the detector lamp. Lamp intensities are typically in the range 1000 to 4000 with a maximum of 4095.

Press EXIT to return to the normal display

TUTOR



NO 2000  
205 10:15 Feb 15



Lamp intensity  
3985

## Chapter 2 Operation



Battery level, V  
8.3

BATTERY PACK  
CRITICALLY LOW



Max 112 ppm  
240 10:12 Feb 15

Press CLEAR  
to reset Max

Max cleared  
240 10:12 Feb 15

**2.5 BATT**

Pressing the **BATT** key displays the current battery level. The battery voltage will be shown for 15 seconds and then the display reverts to normal. The normal operating voltage range is 6 to 8.5 volts.

When LoBar is displayed there is approximately 10 minutes of operation left. If operation is continued with a low battery pack another message will appear indicating that the batteries are critically low. MicroTIP will now turn off the detector lamp. To continue normal operation replace the discharged battery pack with a fully charged one. Recharge the discharged battery pack for at least 8 hours as soon as it is convenient.

**Note:** Deep discharging the battery pack will result in loss of recorded data, setup parameters and may cause damage to the battery pack.

Do not remove, replace or charge the battery pack in a hazardous location.

**2.6 MAX**

Press the **MAX** key. The maximum concentration, the Event during which it was encountered, and the time and the date of the occurrence will be displayed. This is shown for 15 seconds and then the display reverts to normal.

Press **MAX** and then press **CLEAR** twice to reset the Max register. "Max Cleared" will be displayed with the current date and time. After 15 seconds the display reverts to normal.

Recording of real time data is not interrupted when the **MAX** key is pressed or when the Max register is cleared.

**2.7 CLEAR**

**CLEAR** erases the last numerical entry. If a number is entered in error press **CLEAR** to erase the entry and re-enter the correct number. **CLEAR** used in conjunction with the **MAX** key resets the Max register.

## Chapter 2 Operation



Ready 500 ppm  
240 10:28 Feb 15

Event option? ↑↓  
Advance Event

Ready 0.0 ppm  
241 10:35 Feb 15

Event option? ↑↓  
Stop recording

Ready 0.0 ppm  
--- 10:37 Feb 15

Event option? ↑↓  
Delete Event(s)

Delete what? ↑↓  
Range of Events

Start at Event?  
001

Stop with Event?  
241

Ready 0.0 ppm  
241 10:40 Feb 15

**2.8 EVENT**

Events may be used to identify a particular sample or sampling location in memory. Recorded data are played, printed and removed from the datalogger by specifying a start and stop Event number.

The **EVENT** key controls MicroTIP's datalogger. Press the **EVENT** key to see the Event options. Press the arrow keys until the "Advance Event" option is displayed. To increment the current Event number press **ENTER**.

Move to the next Event option by pressing the arrow keys. The datalogger can be turned off by selecting the "Stop recording" option and pressing **ENTER**. MicroTIP will continue to display the current detected concentration but no data will be recorded. There will be no event number shown on the normal display. To begin recording again, press **EVENT** and then **ENTER**. The Event number is automatically incremented by one when the datalogger or the instrument is turned on.

Press the arrow keys to view the next option. The user can delete the current Event, all recorded Events or a range of Events. Press **ENTER** then use the arrow keys to select the desired option and press **ENTER** again. If a range of Events is to be deleted, MicroTIP will ask for the start and stop Event numbers.

To reset the Event counter to 001, select "Delete all Events" and press **ENTER**. After Event 255, MicroTIP resets the Event counter to zero automatically.

**Note:** Deleted information cannot be recovered. It is a good idea to play back or print the contents of the datalogger before deleting any information.

MicroTIP only stores the last Event number seen in a 15 second period. To assign an Event number to a sample, the Event number should be advanced only once every 15 seconds. If the Event number is advanced more than once in a 15 second period, lower Event numbers will not be stored.

MicroTIP can record continuously for a period of 12 hours.

## Chapter 2 Operation

After this time it begins to overwrite existing data one Event at a time. For example: 6 Events of 2 hours each are recorded. Event #7 will overwrite event #1 if it is 2 hours or less in length. If Event #7 is greater than 2 hours it will completely overwrite Event #2 as well. Let's say Event #7 is 3 hours, then Events #3, #4, #5, #6 and #7 are now in the datalogger.

If it is necessary to retain a copy of recorded data, the data should be printed or stored in a computer at least once every 12 hours of operation. This will prevent loss of information when events are overwritten.

**EXIT****2.9 EXIT**

The EXIT key terminates all MicroTIP functions except DISPLAY. When EXIT is pressed the display reverts to normal. Most functions exit automatically if no key is pressed for 15 seconds.

When EXIT is pressed during printing or graphing, MicroTIP stops sending information to the printer. The printer will continue to print until its buffer is empty.

**SETUP****2.10 SETUP**

The SETUP key allows MicroTIP to be set up for a specific application. The current date and time are also set with the SETUP key.

Press SETUP and step through the options. Press ENTER to accept the displayed data or enter a numerical value using the keypad and then press ENTER. If no values are entered the display reverts to normal. To set up the instrument:

1. Press SETUP.
2. The first option sets the full scale range for the bar graph display, the graph output, the audio output, and the 1 volt analog output. Use the up and down arrow keys to select the 20, 200 or 2000 parts per million (ppm) range. This does not affect MicroTIP's numeric display and datalogging.

Range 0-? ppm ↑↓  
1200

## Chapter 2 Operation

Cal memory ? ↑↓  
1



4  
AUDIO

Audio output? ↑↓  
Off

Audio output? ↑↓  
Audio on Alarm

Audio output? ↑↓  
Continuous Audio

9  
ALARM

Alarm at ? ppm  
100.00

3. MicroTIP has 10 Cal Memories for regular operation and one for High Sensitivity operation. Only one Cal Memory can be used at a time. Select Cal Memory 1 with the up and down arrow keys and press ENTER.

**Note:** No matter which Cal Memory is selected, MicroTIP's response is not specific to any one compound. The reading displayed represents the total concentration of all photoionizable compounds in the sample.

4. Next enter the correct values for the current time. Press ENTER after each value.
5. Enter the numerical values for the day, month and year. Again press ENTER after each selection.

**2.11 AUDIO**

To connect the headset (Photovac Part No. 395030)

1. Remove the dust cap from the I/O connector with the dust cap removal key and plug in the headset.
2. Press the AUDIO key and use the arrow keys to select one of three options for audio output and press ENTER.

Audio output can be turned off altogether, set so there is audio output during an alarm condition only, or a continuous audio signal with the tone frequency being proportional to the detected concentration. The volume is controlled by a knob on the headset.

MicroTIP is not UL®-classified for use in hazardous locations with a headset.

**2.12 ALARM**

The ALARM key displays the current alarm level and allows a new alarm level to be entered.

1. Press ALARM to display the current alarm level. If this value is correct, press EXIT to return to the normal display.

## Chapter 2 Operation

2. If a new value is to be set, enter the value, and press ENTER.

When an alarm condition is detected the instrument status changes to "Alarm" and an audio signal is heard through the headset (only if "Audio on Alarm" is selected) and remains on until the alarm condition has passed or until it is turned off with the AUDIO key.

MicroTIP is not UL-classified for use in hazardous locations with a headset.

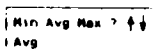
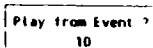
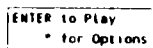
### 2.13 PLAY

The PLAY key plays back previously recorded data. If either "Audio on Alarm" or "Continuous Audio" is selected the playback audio output (not the real time output) is heard through the headset. To enable playback audio output, press AUDIO and select the desired output before pressing the PLAY key.

MicroTIP is not UL-classified for use in hazardous locations with a headset.

1. Press PLAY. Two options are available. Pressing ENTER begins playback where it was last stopped. Press the SETUP (\*) key to set the playback options.
2. Enter the start Event. If this Event is not available MicroTIP begins at the next higher Event. An Event may not be available if the Event number was advanced more than once in 15 seconds, or if the selected Event has been deleted or overwritten.
3. Next select which value is to be displayed, either the Minimum, the Average, or the Maximum, with the arrow keys and press ENTER.
4. The data can be played back in either numerical or graphical display by pressing the DISPLAY key.

When MicroTIP is playing back recorded data it is also measuring and recording real time concentrations even though the instrument status is "Play". If, during playback, an instrument status with a priority higher than that of



## Chapter 2 Operation

"Play" is encountered in real time operation it will be displayed, but MicroTIP will continue to play back.

Playback speed can be increased or decreased by pressing the arrow keys. Information can also be viewed in the opposite direction, again by pressing the arrow keys. A forward arrow (>) appears in the display if data are being played forward or a backward arrow (<) if the data are being played in reverse.

Press ENTER to freeze the display at any time and use the arrow keys to resume playback. Press EXIT to return to the normal display.

The PLAY function provides a speed search to find the desired start and stop Event numbers for printing or graphing.

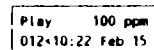
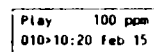
### 2.14 CAL

MicroTIP must be calibrated in order to display concentration in units equivalent to ppm. First a supply of zero air, which contains no ionizable gases or vapors, is used to set MicroTIP's zero point. Then, span gas, containing a known concentration of a photoionizable gas or vapor, is used to set the sensitivity.

Usually clean ambient air will be suitable as zero air. If there is any doubt, use a commercial source of zero grade air and a second sampling bag. Span gas of the desired compound and concentration, required for calibration, may be obtained from a specialty gas supplier. See Appendix B.

Isobutylene at 100 ppm in air is recommended as span gas. To calibrate the instrument use the Calibration Kit (Photovac Part No. 390033) as follows:

1. Connect the supplied regulator to the span gas cylinder. Hand tighten the fittings. Observe proper handling techniques for all gases.
2. Open the valve on the gas bag by turning the valve stem fully counterclockwise.



## Chapter 2 Operation

Cal memory ?  $\uparrow\downarrow$   
7

Response factor?  
1.00

Connect zero gas  
then press ENTER

Calibrating now,  
please wait....

Span conc ? ppm  
100.00

Connect span gas  
then press ENTER

Calibrating now,  
please wait....

3. Attach the nut to the regulator. Hand tighten the fittings.
4. Turn the regulator knob counterclockwise about half a turn to start the flow of gas.
5. Fill the gas bag about half full and then close the regulator fully clockwise to turn off the flow of gas.
6. Disconnect the bag from the adapter and empty it. Flush the bag a few times with the span gas and then fill it.
7. Close the gas bag by turning the valve clockwise.
8. Press SETUP and select the desired Cal Memory with the arrow keys and press ENTER. Press EXIT to return to the normal display.
9. Press CAL and enter the desired response factor. Use Table 2, on page 21, to find the correct response factor for the compound of interest. If the compound is not in Table 2 or you are not looking specifically for one compound then enter 1.00.  
  
The concentration detected by MicroTIP will be multiplied by the response factor before it is displayed and logged.
10. Expose MicroTIP to zero air. Press ENTER and MicroTIP sets its zero point.
11. MicroTIP then asks for the span gas concentration. Enter the known span gas concentration and then connect the span gas bag adapter to the inlet.
12. Press ENTER and MicroTIP sets its sensitivity.
13. When MicroTIP's display reverts to normal, MicroTIP is calibrated and ready for use. Remove the span gas bag from the inlet.

MicroTIP has 10 Cal Memories and can be calibrated with 10 different span gases or response factors if desired. Only one Cal Memory can be used at a time. Each memory stores

## Chapter 2 Operation

a different response factor, zero point and sensitivity. To program the Cal Memories.

1. Press SETUP and select the desired Cal Memory (1 to 10) with the arrow keys
2. Exit from SETUP and press the CAL key
3. Enter the desired response factor and press ENTER

Note: It does not matter which Cal Memory is selected or which response factor is entered. MicroTIP's response is not specific to any one compound. The reading displayed represents the total concentration of all photoionizable compounds in the sample.

4. Follow the displayed calibration instructions. When the calibration is completed it is automatically stored in the selected Cal Memory. The span gas concentration entered here is specific to the selected Cal Memory.

Whenever the instrument is calibrated, MicroTIP updates the selected Cal Memory only. The instrument should be calibrated at least once a day.

## 2.15 PRINT

MicroTIP was designed to be used with an Epson® FX 80 or 100% compatible printer with an RS232 serial interface. If an Epson compatible printer is to be used, the printer cable and suitable adapter (Photovac Part No. 395006) should work.

The printer must be set to 8 data bits and 1 stop bit to communicate with MicroTIP. MicroTIP's baud rate and parity must be set depending on the printer requirements. Refer to the printer user's manual for more information.

MicroTIP is not UL-classified for use in hazardous locations with printers.

When MicroTIP is printing data it is also measuring real time concentrations. To print recorded data:

## Chapter 2 Operation

ENTER to Print  
\* for Options

Start at Event?  
1

Stop with Event?  
2

Output format?  $\updownarrow$   
Fit on one page

Output format?  $\updownarrow$   
Output all data

ID number?  
15008

Baud rate?  $\updownarrow$   
9600

Parity?  $\updownarrow$   
None

1. Use the printer cable and suitable adapter (Photovac Part No. 395006) to connect the MicroTIP I/O connector to the printer.

2. Press the PRINT key and then the SETUP (\*) key to select the desired setup options.

3. MicroTIP will ask for the number of the start and stop Events. Enter the desired values and press ENTER.

4. MicroTIP will then ask if the selected data are to be formatted to fit on one 8 1/2" x 11" page or if all recorded data between the selected start and stop Events are to be printed. Use the arrow keys to select the desired option and press ENTER.

5. Enter an ID number if desired. Any number up to 16 digits long may be entered as an ID number. The ID number can be used to differentiate between users or instruments. If more than one user is using a single instrument, each user will use an individual number for printed reports. If more than one MicroTIP is being used, each instrument can have its own ID number on printed reports.

If an ID number is not required, leave this option blank and move to the next option by pressing ENTER.

6. Enter the baud rate and parity. These values are specific to the printer being used and must be set correctly. Again, refer to the printer user's manual to determine the correct baud rate and parity.

7. When the setup is correct, ensure the printer is on line and press ENTER.

If "Fit on one page" is selected, MicroTIP will divide the selected data into 54 averaging intervals. One interval is printed on each line.

MicroTIP stores one set of readings (Min, Avg and Max) each 15 seconds. In each averaging interval the printed minimum is the minimum of all the stored readings in that

## Chapter 2 Operation

Photovac MicroTIP Statistical Summary Report

ID Number	Interval	Min	Avg	Max	Status	Average
Feb 02 92	12:00	0.0	0.0	0.0	Ready	
	12:15	0.0	0.0	0.0	Ready	
	12:30	0.0	0.0	0.0	Ready	
	12:45	0.0	0.0	0.0	Ready	
	13:00	0.0	0.0	0.0	Ready	
	13:15	0.0	0.0	0.0	Ready	
	13:30	0.0	0.0	0.0	Ready	
	13:45	0.0	0.0	0.0	Ready	
	14:00	0.0	0.0	0.0	Ready	
	14:15	0.0	0.0	0.0	Ready	
	14:30	0.0	0.0	0.0	Ready	
	14:45	0.0	0.0	0.0	Ready	
	15:00	0.0	0.0	0.0	Ready	
	15:15	0.0	0.0	0.0	Ready	
	15:30	0.0	0.0	0.0	Ready	
	15:45	0.0	0.0	0.0	Ready	
	16:00	0.0	0.0	0.0	Ready	
	16:15	0.0	0.0	0.0	Ready	
	16:30	0.0	0.0	0.0	Ready	
	16:45	0.0	0.0	0.0	Ready	
	17:00	0.0	0.0	0.0	Ready	
	17:15	0.0	0.0	0.0	Ready	
	17:30	0.0	0.0	0.0	Ready	
	17:45	0.0	0.0	0.0	Ready	
	18:00	0.0	0.0	0.0	Ready	
	18:15	0.0	0.0	0.0	Ready	
	18:30	0.0	0.0	0.0	Ready	
	18:45	0.0	0.0	0.0	Ready	
	19:00	0.0	0.0	0.0	Ready	
	19:15	0.0	0.0	0.0	Ready	
	19:30	0.0	0.0	0.0	Ready	
	19:45	0.0	0.0	0.0	Ready	
	20:00	0.0	0.0	0.0	Ready	
Feb 04 92	00:00	0.0	0.0	0.0	Cal	
	00:15	0.0	0.0	0.0	Cal	
	00:30	0.0	0.0	0.0	Cal	
	00:45	0.0	0.0	0.0	Cal	
	01:00	0.0	0.0	0.0	Cal	
	01:15	0.0	0.0	0.0	Cal	
	01:30	0.0	0.0	0.0	Cal	
	01:45	0.0	0.0	0.0	Cal	
	02:00	0.0	0.0	0.0	Cal	
	02:15	0.0	0.0	0.0	Cal	
	02:30	0.0	0.0	0.0	Cal	
	02:45	0.0	0.0	0.0	Cal	
	03:00	0.0	0.0	0.0	Cal	
Feb 17 92	12:00	0.0	0.0	0.0	Cal	
	12:15	0.0	0.0	0.0	Cal	
Feb 24 92	12:00	0.0	0.0	0.0	Cal	

Figure 3 Printed Output

interval. The printed Avg is the average of all the recorded average readings and the Max is the maximum of all the recorded maximum readings.

The following information is printed:

- a. The number of readings in an interval and the length of the interval are printed at the top of the page. In Figure 3 there are 39 readings in an interval and the interval is 585 seconds
- b. The interval start time. The first interval in Figure 3 begins at 12:10

## Chapter 2 Operation

- c. The lowest Event number in the interval, only if the Event number has changed.
- d. The highest priority instrument status of the interval. See page 38 for a description of the instrument status.
- e. Space for the user to add Notes to the report. Notes could include identification of particular samples or sampling location based on Event numbers.

If "Output all data" is selected the header, containing the title, averaging interval and column headings, will only be printed on the first page of the printed output. Each of the following pages will contain 66 lines of data.

To print all 12 hours of recorded data will require about 45 pages and take about 10 minutes. The actual printing time will depend on the printer and print quality. While the information is being printed, the display shows that printing is in progress. The keypad will not accept commands until the present print job has been completed.

Pressing EXIT during printing stops the job and the display reverts to normal. The printer will continue to print until its buffer is empty.

## 2.16 GRAPH

Pressing the GRAPH key prints the recorded data but in graphical format. When MicroTIP is graphing recorded data it is also measuring and recording real time concentrations.

MicroTIP is not UL-classified for use in hazardous locations with printers.

1. Press SETUP to set the range for the graph. Use the arrow keys to select the 20, 200 or 2000 ppm range.
2. Use the printer cable and suitable adapter (Photovac Part No. 395006) to connect the MicroTIP I/O connector to the printer.

Printing now  
please wait...



Range 0-? ppm  
200

## Chapter 2 Operation

ENTER to Graph  
\* for Options

Start at Event?  
1

Stop with Event?  
2-

Min Avg Max ?  $\uparrow \downarrow$   
Avg

Output format?  $\uparrow \downarrow$   
Fit on one page

Output format?  $\uparrow \downarrow$   
Output all data

ID number?  
25008

Baud rate?  $\uparrow \downarrow$   
9600

Parity?  $\uparrow \downarrow$   
None

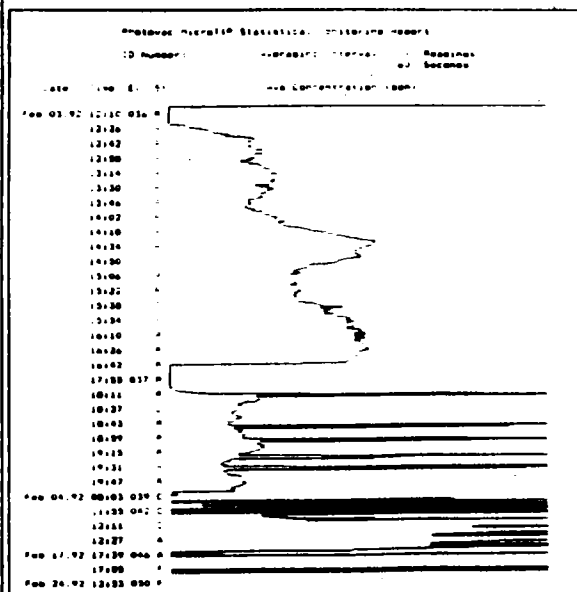
3. Press the GRAPH key and then the SETUP (\*) key to select the desired setup options
  4. MicroTIP will ask for the number of the start and stop Events. Enter the desired values and press ENTER.
  5. Select which values are to be graphed. Use the arrow keys to select from:
 

a. Min	e. Min & Max
b. Avg	f. Avg & Max
c. Max	g. Min & Avg & Max
d. Min & Avg	
  6. MicroTIP will then ask if the selected data are to be formatted to fit on a single 8 1/2" x 11" page or if all recorded data between the selected start and stop Events are to be graphed. Use the arrow keys to select the desired option and press ENTER
  7. Enter an ID number if desired. Any number up to 16 digits long may be entered as an ID number. The ID number can be used to differentiate between users or instruments. If more than one user is using a single instrument, each user will use an individual number for printed reports. If more than one MicroTIP is being used, each instrument can have its own ID number on printed reports
- If an ID number is not required, leave this option blank and move onto the next option by pressing ENTER.
8. Enter the baud rate and parity. These values are specific to the printer being used and must be set correctly. Again, refer to the printer user's manual to determine the correct baud rate and parity
  9. When the setup is correct, ensure the printer is on line and press ENTER.

If "Fit on one page" is selected, MicroTIP will divide the selected data into the appropriate averaging intervals. Sixteen intervals are graphed on each line

## Chapter 2 Operation

MicroTIP always stores one set of readings (Min, Avg and Max) each 15 seconds. In each averaging interval the graphed minimum is the minimum of all the stored readings in that interval. The graphed Avg is the average of all the recorded average readings and the Max is the maximum of all the recorded maximum readings.



**Figure 4 Graphed Output**

The following information is printed:

- The number of readings in an interval and the length of the interval are printed at the top of the page. In Figure 4 there are 4 readings in an interval and the interval is 60 seconds.
- Time is printed once every 16 intervals or every 16 minutes for the example in Figure 4. This time will be the start time of the next 16 intervals.

## Chapter 2 Operation

- The lowest Event number of the 16 intervals is printed, only if it has changed from the previous set of 16 intervals.
- The highest priority instrument status code of the 16 intervals is printed.

If "Output all data" is selected the header, containing the title, averaging interval and column headings, will only be printed on the first page of the graphed output.

To graph all 12 hours of recorded data will require about 4 pages and take about 10 minutes. The actual printing time will depend on the printer and print quality.

While the information is being printed, the display shows that printing is in progress. The keypad will not accept commands until the present print job has been completed.

Pressing EXIT during printing stops the job and the display reverts to normal. The printer will continue to print until its buffer is empty.

## 2.17 HIGH SENSITIVITY OPERATION

MicroTIP can be used as a high sensitivity leak detector. In High Sensitivity operation, MicroTIP does not read directly in ppm but displays a reading proportional to the total concentration of photoionizable gases and vapors detected.

During calibration, no span gas is required. MicroTIP zeros its reading with zero air and then sets itself to the maximum sensitivity.


- Press SETUP. Select the 0-20 ppm display range with the arrow keys and press ENTER.
- Select High Sensitivity with the arrow keys and press ENTER.
- Press EXIT. Select the bar graph with the DISPLAY key.
- Press CAL and calibrate MicroTIP with zero air. High Sensitivity operation does not require span gas.

Range 0-20 ppm  
200

Cal memory ?  
High Sensitivity

NO 20  
244 11:15 Feb 15

## Chapter 2 Operation

Audio output:   
Continuous Audio

5. Press AUDIO and select "Continuous Audio" with the arrow keys.

As MicroTIP samples air closer to the leak, the length of the shaded area on the display increases. When used with the optional headset (Photovac Part No. 395030), the frequency of the tone increases as air closer to the leak is sampled, and the user need not watch the display.

MicroTIP is not UL-classified for use in hazardous locations with a headset.

MicroTIP's 3 second response time and detection limit of 0.1 ppm isobutylene permit fast detection of small leaks.

## 2.18 RESPONSE FACTORS FOR GASES AND VAPORS

In situations where only a single pure compound is present in air, MicroTIP should be calibrated with a standard of that specific compound as span gas. MicroTIP's 10 Cal Memories can be used to store calibration information for 10 different span gases.

MicroTIP's reading will always be influenced by any other photoionizable compounds present in the air sample. Even if MicroTIP has been calibrated with a specific compound, its response is not specific and the presence of another impurity may render the numerical result invalid.

It is often impractical to carry a range of different standards into the field. Approximate results can be obtained by calibrating MicroTIP with the recommended span gas and entering the appropriate response factor. The response factor is based on the ratio of the response of the specific compound to the response of the span gas. The response factor multiplies MicroTIP's reading then displays and records it (if the datalogger is on).

Table 2 gives response factors from which approximations can be made for guidance purposes. Data extrapolated from the use of response factors must be regarded as interim and approximate only. Table 2 should be used only for concentrations up to 100 ppm of the specific compound, because response factors change with concentration.

## Chapter 2 Operation

To use the data in Table 2

1. Press the CAL key and enter the response factor for the specific compound
2. Calibrate MicroTIP with zero air and 100 ppm span gas as described in Section 2.14
3. Expose MicroTIP to the sample. The displayed reading is the approximate concentration of the specific compound.

Compound	Response Factor
Acetone	1.2
Benzene	0.6
Butyl Acetate	2.9
Cyclohexane	1.9
Cyclohexanone	0.9
Ethyl Acrylate	3.3
n-Heptane	3.7
Methyl Ethyl Ketone	0.9
Methyl Isobutyl Ketone	1.1
Methyl Methacrylate	1.5
n-Octane	2.6
Perchloroethylene	0.7
Styrene	0.5
Toluene	0.5
Trichloroethylene	0.6

**Table 2 Response Factors**

Note: These response factors serve as a guide to concentrations measured by MicroTIP with a 10.6 eV lamp. Results are expected to be accurate to within  $\pm 10$  ppm or  $\pm 25\%$  of result, whichever is greater. Accuracy of response factors to other gases and vapors may differ from that stated.

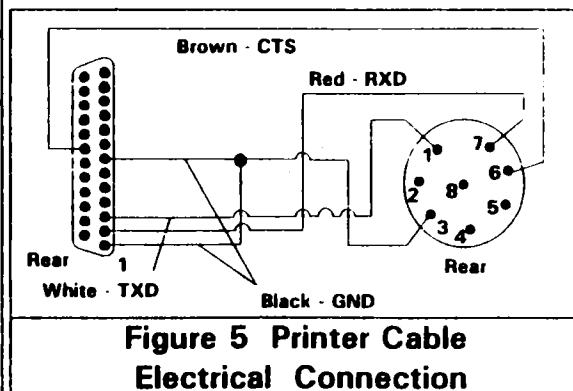
These responses are measured relative to isobutylene span gas

## Chapter 3 Accessories and Other Devices

### 3.1 PRINTER

MicroTIP is designed to interface with an Epson FX-80 or 100% compatible printer with an RS232 serial interface. The printer cable (Photovac Part No. 395006) has been configured for this application only. If the printer being used is compatible with the Epson FX-80, then the supplied printer cable should work. If it does not work then a different cable may be required or the existing one may require modification. If you are unsure of the compatibility of the printer refer to the printer user's manual or contact the printer manufacturer.

In order to modify the existing printer cable the pinout information for the printer connector is required. Refer to the printer user's manual for specific details. The pinouts for the MicroTIP printer cable are shown in Figure 5 and are listed in Table 3. If modifying the cable is not possible, take the electrical and pinout information to a computer store where a suitable adapter may be obtained.



Once the proper cable has been obtained, ensure the printer is set to 8 data bits and 1 stop bit for communication and that the appropriate baud rate and parity have been selected. Use the PRINT and GRAPH keys as detailed in Sections 2-15 and 2-16.

MicroTIP I/O Conn. (8 pin) Pin #	MicroTIP Printer Cable (DB25) Pin #	Standard RS 232	Color
1	3	TXD	White
2	—	—	—
3	1 & 7	GND	Black
4	—	—	—
5	—	—	—
6	20	CTS	Brown
7	2	RXD	Red
8	—	—	—

**Table 3 Printer Cable Pinouts**

MicroTIP is not UL-classified for use in hazardous locations with printers.

### 3.2 COMPUTER

MicroTIP will send information stored in its datalogger to a computer. The computer must be set up to emulate a terminal. The use of Crosstalk® a communications software package, is recommended.

MicroTIP is set to 8 data bits and 1 stop bit for communication. The appropriate baud rate and parity must be selected. Use the PRINT key as detailed in Section 2-15.

Use the printer cable and a suitable adapter (Photovac Part No. 395006) to connect MicroTIP to the computer's serial port. The serial port may be labelled Com1 or Com2. Refer to the computer user's manual to determine the baud rate and parity as these values will depend on the computer.

The baud rate can be set from 300 to 19200. The parity can be set to Odd, Even or None and again will depend on the computer. The port number will be the computer port to which MicroTIP is connected. Stop Bits must be set to 1. Correspondingly, Data Bits must be set to 8.

The following instructions are for Crosstalk Mark IV Version 2.0. The commands may vary depending on which version of Crosstalk is being used.

## Chapter 3 Accessories and Other Devices

To initiate communications between MicroTIP and the computer:

1. **Start Crosstalk.** From the dialing directory select **DIRECT** and press Alt-S. A dialing directory entry will be created for communications with MicroTIP.
2. **Enter the name of the dialing directory entry.** Type in **MicroTIP** as the name.
3. **Leave the Description as Direct <hardwired> connection.**
4. **Leave the Number option blank** as there is no telephone number to be dialed.
5. **Press the spacebar** to turn the Capture option on. This option will store the data received from MicroTIP to the specified download directory.
6. **Type in the Download Directory.** This is the disk drive and directory, on the computer, to which MicroTIP data will be stored.
7. **The Device should be selected as Modem** even though a modem is not being used.
8. **Enter the Computer Port** to which MicroTIP has been connected. The port number will depend on how Crosstalk was configured when it was installed. **Ensure MicroTIP has been connected to a serial port.** See Section 5.3. MicroTIP will not work with a parallel port.
9. **Set the desired speed.** Ensure it matches the baud rate set on MicroTIP.
10. **Set the WordFormat.** Stop Bits must be set to 1, and Data Bits to 8. Parity may be set to odd, even or none depending on the computer.
11. **Press Ctrl-Enter** to save the dialing directory entry. This entry may be saved with Crosstalk. Whenever Crosstalk is run, the MicroTIP entry will appear in the dialing directory. If nothing has changed this entry

## Chapter 3 Accessories and Other Devices

may be used every time MicroTIP is connected to the computer. This will save the user having to set up Crosstalk each time.

12. **Ensure the MicroTIP entry is selected** in the dialing directory and press Enter.
13. **Ensure the MicroTIP print setup matches** that entered in the Crosstalk dialing directory and then press the **MicroTIP PRINT** key. The data will now appear in the Crosstalk communications window. It will be stored as it appears on the screen.
14. **When all the data has been sent** press Alt-C and turn the capture option off and then press Enter.
15. **Press Alt-O** to end the communications session.

The captured file will have an extension that corresponds to the current date. Convert this file to a text file using the MS DOS® Copy Command:

16. **At the DOS prompt type:**  
Copy MICROTIP.814 MICROTIP.prn

17. **The newly created file MICROTIP.prn can now be imported** into Lotus 1-2-3® as a text file. See the Lotus 1-2-3 User's Manual for details.

MicroTIP is not UL classified for use in hazardous locations with computers.

### 3.3 CHART RECORDER

MicroTIP's output can be displayed as a 0 to 1 volt analog voltage on a chart recorder in real time. Set the chart recorder to 1V full scale and connect it to MicroTIP's I/O connector using the analog output cable (Photovac Part No. 395005). The concentration range of the analog output signal is selected with the SETUP key, and can be set to 20, 200, or 2000 ppm full scale.

MicroTIP is not UL classified for use in hazardous locations with chart recorders.



### 3.4 SAMPLE BAG

MicroTIP is equipped with a sample outlet fitting (See Figure 1) from which samples may be collected for further analysis. Connect a sample bag to the fitting with a short length of 1/8" inside diameter flexible tubing.

**Note:** Readings may fluctuate due to changes in detector flow rate as the sample bag is filling. The bag contents will not perfectly represent the sample. Ozone produced by MicroTIP's detector will be present, and sample composition may have been altered by passage through MicroTIP's sampling pump.

### 3.5 THREE METER (9.8') SAMPLE LINE

For remote sampling, connect the 3m (9.8') sample line (Photovac Part No. 390006) to MicroTIP's sample inlet in place of the 17cm (6.8") sample line supplied.

### 3.6 SHOULDER STRAP

Snap one end of the shoulder strap to the steel shoulder strap connector bail above MicroTIP's I/O connector. Snap the other end to one of the shoulder strap connectors beside the display. The connection point is selectable for right or left handed operation. Adjust the shoulder pad and strap length for comfort.

### 3.7 HEADSET

To connect the headset:

1. Remove the dust cap with the dust cap removal key.
2. Connect the headset (Photovac Part No. 395030) to the I/O port and tighten the locking nut.
3. Use the knob on the headset to adjust the volume.

Operation of the headset is described in Sections 2.11-2.13.

MicroTIP is not UL-classified for use in hazardous locations with a headset

### 3.8 REPLACEMENT DETECTOR LAMPS

MicroTIP is supplied with an ultraviolet (UV) lamp which produces an energy of 10.6 electron-volts (eV). With this standard lamp installed, MicroTIP responds well to gases and vapors which ionize at 10.6 eV or less. Some of these are listed, with their response factors, in Table 2. For special applications, MicroTIP's response can be changed by using other lamps.

With a 9.5 eV lamp, MicroTIP responds well only to gases and vapors which ionize at 9.5 eV or less. Some response factors with a 9.5 eV lamp are listed in Table 4 on page 28. To use the 9.5 eV lamp, MicroTIP must be calibrated with a compound which ionizes at below 9.5 eV. Toluene at 100 ppm in air is recommended.

Table 4 gives response factors from which approximations can be made for guidance purposes. Data extrapolated from the use of response factors must be regarded as interim and approximate only. Table 4 should be used only for concentrations up to 100 ppm of the specific compound, as response factors change with concentration. Data from Table 4 may be used in the same way as those from Table 2 if a single pure compound in air is being sampled.

1. Press the CAL key and enter the response factor for the specific compound.
2. Calibrate MicroTIP with zero air and 100 ppm toluene span gas as described in Section 2.14.
3. Expose MicroTIP to the sample. The displayed reading is the approximate concentration of the specific compound.

In a situation where a range of gases and vapors exists, MicroTIP displays a reading representing the total concentration of photoionizable compounds present. The change in the response factor given by the 9.5 eV lamp is especially useful when sampling mixtures, for example, a mixture of benzene and trichloroethylene. Both compounds are detected with MicroTIP, and benzene is the more toxic of the two. For health protection, a relatively higher response to benzene and a lower response to trichloroethylene are

desired in order to detect lower concentrations of benzene in the presence of trichloroethylene.

COMPOUND	RESPONSE FACTOR
Acetone	20
Benzene	1.2
Methyl Isobutyl Ketone	2.5
Perchloroethylene	1.8
Toluene	1.0
Trichloroethylene	4.0

**Table 4 Response Factors with  
9.5 eV Lamp**

**Note:** These response factors serve as a guide to concentrations measured by MicroTIP with a 9.5 eV lamp. Results for compounds with response factors of 3.3 and below are expected to be accurate to within  $\pm 10$  ppm or  $\pm 25\%$  of result, whichever is greater. Results for compounds with response factors above 3.3 are expected to be accurate to within  $\pm 40\%$  of result. Accuracy of response factors for other gases and vapors may differ from that stated.

These responses are measured relative to toluene span gas.

The response factors in Tables 2 and 4 are inversely proportional to MicroTIP's response to a specific chemical, that is, a low response factor means that MicroTIP has a high response.

With a 10.6eV lamp, the response factor of benzene is 0.6 and that of trichloroethylene is 0.6 (from Table 2).

10.6eV response ratio (benzene/trichloroethylene from Table 2:

$$= \frac{1/0.6}{1/0.6} \\ = 1$$

With a 9.5eV lamp the response ratio (benzene/n-octane) from Table 4:

$$= \frac{1/1.2}{1/4.0} \\ = 3.3$$

The response ratio for the 9.5eV lamp is about three times that for the 10.6eV lamp. Because of this difference in response, benzene vapor from the mixture contributes more to the MicroTIP reading with the 9.5 eV lamp than it does with the 10.6 eV lamp. MicroTIP with the 9.5 eV lamp is therefore better suited to detecting benzene in the presence of trichloroethylene.

The 9.5 eV lamp is installed, maintained, and removed according to the instructions in Section 4.2.

With an 11.7 eV lamp installed, MicroTIP functions as a leak detector responding to gases and vapors which ionize at 11.7 eV or less. This lamp is intended for High Sensitivity operation only. It is not suitable for direct-reading use, because of limitations of the lamp window material.

The 11.7 eV lamp window material is Lithium Fluoride (LiF). Unlike other lamp windows, LiF readily absorbs water from atmospheric humidity. When contaminated by moisture, the window loses its ability to transmit UV light.

**Note:** Never touch the window or let liquid water near it.

Furthermore, LiF is composed of two light elements which are easily disrupted within the crystal lattice by the same UV light generated by the lamp. Disruption of the lattice causes the crystal to turn a yellowish color, and again performance declines.

The 11.7 eV lamp is useful for detecting leaks of chemicals not ionized by the 10.6 eV lamp.

Carbon tetrachloride can be used as an example. Set MicroTIP to display a bar graph. The length of the shaded area on the display represents the concentration of carbon tetrachloride (and other ionizables) in the sample. As MicroTIP samples air closer to the carbon tetrachloride source, the display indicates higher concentrations.

Numerical values shown on MicroTIP's display should not

## Chapter 3 Accessories and Other Devices

Range 0-20 ppm  $\uparrow\downarrow$   
200

Cal memory ?  $\uparrow\downarrow$   
High Sensitivity

NO            20  
244 11:15 Feb 15

Connect zero gas  
then press ENTER

be interpreted as parts per million concentrations. They indicate only the relative presence or absence of ionizable gases and vapors. MicroTIP's 3 second response time and detection limit of 10 ppm carbon tetrachloride permit fast determination of small leaks.

Because of the lamp window limitations, the lifetime of the 11.7 eV lamp is restricted and it must be used sparingly according to these instructions:

1. Remove the 11.7 eV lamp from the supplied dessicant bottle and install the lamp according to the instructions in Section 4.2.
2. Switch on MicroTIP, wait for it to warm up, and press SETUP.
3. Select the 0-20 ppm range with the arrow keys and press ENTER.
4. Select High Sensitivity with the arrow keys and press ENTER.
5. Press EXIT and then select the bar graph with the DISPLAY key.
6. Press CAL and calibrate MicroTIP with zero air. High Sensitivity operation does not require a response factor or span gas.
7. Every 15 minutes of operation, recalibrate MicroTIP with zero air.
8. Every hour of operation, switch off MicroTIP and examine the lamp window for yellowing. If the window is yellow, then remove the lamp and regenerate the window according to the procedure below.
9. After use, remove the lamp from MicroTIP and store it in the supplied dessicant bottle.

To regenerate the 11.7 eV lamp window:

1. Clean the lamp window with dry aluminum oxide powder on a dry cotton swab. Do not use methanol

## Chapter 3 Accessories and Other Devices

or water.

Aluminum oxide may be obtained from most chemical supply companies. When ordering specify 3.0 micron powder.

2. Heat the lamp in a 150°C (300°F) oven for 8 hours or more.
3. Allow the lamp to cool before use.
4. Alternatively, the lamp window can be regenerated without heat by storing the lamp in a dessicator for at least 5 days.

## Chapter 4 Routine Maintenance

### 4.1 CHARGING THE BATTERY

When the instrument status reads LoBat, the MicroTIP battery pack requires recharging. A fully charged battery powers MicroTIP for 7 hours. If the instrument is to be used for more than 7 hours, carry a spare battery pack. When the first one has been discharged, replace it with the spare. Upon return from field work, recharge both battery packs as outlined in Section 1.2. Two chargers are required to do this overnight. Use only the IS-3000 battery charger (Photovac Part No. 395016/17).

The charger automatically charges at a high charge rate until the battery is fully charged and then maintains the full charge with a low continuous charge rate indefinitely so there is no danger of over-charging.

**Note:** Leaving MicroTIP for more than three days without a charged battery pack will result in loss of recorded data and setup parameters. Charge the battery pack for at least 8 hours and put it back onto the instrument.

Do not remove, replace, or charge the battery pack in a hazardous location.

If MicroTIP is not used regularly, the battery should be charged at least once a month for between 8 and 72 hours.

### 4.2 CLEANING THE LAMP WINDOW

During the course of normal operation a film builds up on the window of the detector lamp. The rate at which the film develops depends on the type and concentration of the gases and vapors being sampled and results from the UV light interacting with them. As a guide, clean the window every 24 hours of operation.

Do not clean the detector lamp in a hazardous location.

1. Ensure the instrument is turned off.
2. Hold the black detector housing in one hand and

LoBat 100 ppm  
250 14:20 Feb 15



unscrew it from the body of MicroTIP. Remove the housing, being careful not to lose the o-ring seal on top of the photoionization detector. The detector cell, lamp holder, and high frequency (HF) driver circuit board are now exposed.

3. Unplug the red and yellow wires from the HF driver circuit board.
  4. Locate the black ground wire. Loosen the screw on the HF driver circuit board and disconnect the black wire.
  5. Hold the lamp holder in one hand so it will not rotate and carefully unscrew the detector cell with the red, yellow and black wires attached.
- Note:** Do not touch the fine wire mesh inside the detector cell. Any dust or dirt in the detector cell can be blown out with a gentle jet of compressed air.
6. Leaving the lamp spring in place, remove the lamp from the lamp holder.
  7. To remove the film, gently rub the window of the lamp with a lint free tissue moistened with methanol. Use only HPLC grade or spectroscopic grade methanol to clean the lamp window.
  8. Allow the window to dry and then, without touching the window, replace it in the lamp holder.
  9. Replace the detector cell squarely on the lamp holder. Finger tighten only. Do not over-tighten.
  10. Replace the black wire below the screw on the HF driver circuit board and tighten the screw down. Plug the yellow wire onto the gold pin and the red wire onto the silver pin on the HF driver circuit board.
  11. Check the lamp holder and ensure it is securely seated by hand. Check that the o-ring seal is in position. Replace the detector housing and tighten by hand.

Calibrate MicroTIP and then continue normal operation.



Fault 0.0 ppm  
251 14:50 Feb 15

Detector light  
intensity is low

#### 4.3 REPLACING THE DETECTOR UV LAMP

Do not replace the detector lamp in a hazardous location.

If the lamp has failed then it requires replacement:

1. Remove the lamp as outlined in Section 4.2.
2. Remove the lamp spring from the lamp holder and replace it with the new lamp spring.
3. Without touching the window of the new lamp carefully place it in the lamp holder.
4. Replace the detector cell and the detector housing as outlined in Section 4.2.

Once calibrated, MicroTIP is ready for operation.

#### 4.4 REPLACING THE INLET FILTER

MicroTIP is equipped with a dust filter to reduce detector contamination. As the filter collects dust, MicroTIP's inlet flow rate and sensitivity decrease. Replace the filter every 240 hours of operation, or more frequently if MicroTIP is used in a dusty environment. Do not operate MicroTIP without an inlet filter.

Do not replace the inlet filter in a hazardous location.

1. Turn the instrument off. Hold the filter housing near the detector housing with a  $\frac{9}{16}$ " wrench.
2. Unscrew the top of the filter housing with another  $\frac{9}{16}$ " wrench. Be careful not to lose the metal sealing washer.
3. Remove the spring and filter and install the new filter, open end first. Press the filter into place so it will seal at the bottom of the filter housing. Replace the filter spring and the top of the filter housing. Tighten the top nut while holding the bottom one stationary with the wrench.

Once calibrated, MicroTIP is ready for operation.

## Chapter 5 Troubleshooting

### 5.1 IF MICROTIP DRAWS IN LIQUID

MicroTIP accepts only gas and vapor samples. Aspirating a liquid may result in damage to the lamp and the pump. If water is drawn in, the affected parts of the instrument may be cleaned and dried.

Contact Photovac Service if another liquid is aspirated.

MicroTIP must be serviced away from hazardous locations.

1. Before taking the instrument apart allow MicroTIP to run until no more liquid comes out of the sample outlet fitting below the detector housing. This will clean out the pump.
2. Turn the instrument off. Remove the detector cell and lamp as outlined in Section 4.2.
3. Dry the lamp with a clean lint free tissue and clean the window. See Section 4.2.
4. Clean the detector cell in distilled water, preferably in an ultrasonic cleaner for no more than 5 minutes.

**Note:** Do not touch the fine wire mesh in the detector cell. Do not use solvents as they will degrade the detector cell.

5. Dry the detector cell overnight at 50°C (125°F).
6. Dry the inside of the lamp holder.
7. Remove the filter cartridge as in Section 4.4.
8. Dry the inside of the filter housing.
9. Install a new filter (Photovac Part No. 395000) and re-assemble the filter housing.

Once calibrated, MicroTIP is ready for operation.

## Chapter 5 Troubleshooting

**5.2 INSTRUMENT STATUS AND FAULT DISPLAYS**

The instrument status appears at the left of the upper line of the display and on the Print and Graph outputs. Each status has a priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off.

Status	Code	Priority	Description
Fault	F	1	One of 3 faults is occurring. Press TUTOR for details.
Cal	C	2	Will never be observed on the display during normal operation as various calibration prompt messages are displayed while MicroTIP is calibrating. If the instrument is turned off when it is calibrating with span gas, Cal will appear on the display when MicroTIP is turned on again indicating the last calibration was incomplete. Cal status is also shown on printed and graphed output.
Over	O	3	Detected concentration exceeds 2500 on the display.
Alarm	A	4	Detected concentration exceeds the set alarm level.
LoBat	L	5	Battery pack power is low. Recharge or replace pack.
Play	P	6	The instrument is playing back previously recorded data.
HiSens	H	7	High Sensitivity operation.
Ready	R	8	Normal operation.

**Table 5 Instrument Status**

Detector light  
intensity is low

Signal from zero  
gas is too high

Detector field  
voltage is low

## Chapter 5 Troubleshooting

When the bar graph display or the Graph output is selected the instrument status is reduced to a one letter code. Table 5 summarizes the instrument status and priority.

When the Fault status is displayed, MicroTIP's operation is compromised. Press the TUTOR key for a two line description of the fault.

MicroTIP must be serviced away from hazardous locations

**Fault: Detector light intensity is low**

**Cause:** Defective UV lamp.

**Action:** Replace the lamp. See Section 4.3.

**Cause:** Poor connection between lamp holder and HF driver circuit board.

**Action:** Check the green wire joining the lamp holder to the HF driver circuit board. Ensure that the green wire is securely connected to both the lampholder and to the HF driver circuit board.

**Fault: Signal from zero gas is too high**

**Cause:** Contamination of sample line or fittings before the detector.

**Action:** Clean or replace the sample line or the inlet filter. See Section 4.4.

**Cause:** Span and zero gases mixed up.

**Action:** Ensure clean gas is used to zero MicroTIP and that the span gas is of a reliable concentration.

**Cause:** Contamination in the detector.

**Action:** Clean the detector. See Section 5.1.

**Cause:** Short circuit in the detector.

**Action:** With the detector in place ensure resistance between red and yellow wires exceeds 10 megohms.

**Fault: Detector field voltage is low**

**Cause:** Internal fault in the electronics

**Action:** Contact Photovac Service at (516)254-4283

**5.3 ESTABLISHING COMPUTER COMMUNICATIONS**

If, after having followed the procedure in Section 3.2, communications cannot be established with a computer, the problem may lie with the hardware connections or the printer cable configuration.

1. Ensure MicroTIP is connected to the serial port of the computer.

The serial port will usually be a male connector, typically 9 pins on an IBM-AT® and compatibles and 25 pins on an IBM-XT® and compatibles. The 25 (or more) pin female connector is usually a parallel port. MicroTIP cannot be connected to a parallel port.

An exception to this rule is Tandy® Computers, which use a female 25 pin connector for the serial port.

2. Ensure the cable being used is compatible with the device.

An IBM-AT and compatibles with a 9 pin serial connector will first require a null modem to switch pins 2 and 3. Next a gender changer that converts the male DB25 connector on the printer cable from male 25 pins to female 9 pins is required. These two adapters have been combined into one, which is supplied with the MicroTIP printer cable.

An IBM-XT and compatibles should not require a null modem but will require a gender changer. A gender changer will convert the male DB25 connector on the printer cable to a female connector. A gender changer is supplied with the MicroTIP printer cable.

The pin definitions of interest are listed in Table 6. Only pins 2 and 3 are shown since these are the problem pins:

Pin #	MicroTIP	IBM-AT	IBM-XT
2	Rxd	Rxd	Txd
3	Txd	Txd	Rxd

**Table 6 Pin Definition**

Pins 2 and 3 should be **mismatched** between MicroTIP and the computer. Ensure this is the case. It is also possible that the cable being used may switch pins 2 and 3 even if it is not necessary. i.e. the cable is a null modem. IBM XT cables are usually null modems, since a null modem is required for connection to a printer.

If you are using an IBM-AT and find that a null modem is not required it is possible that an IBM XT serial port has been added to an expansion slot and thus does not require a null modem. The opposite may be the case if an IBM-AT serial port was added to an IBM-XT expansion slot, in which case the null modem is required.

3. Ensure all hardware is working properly.

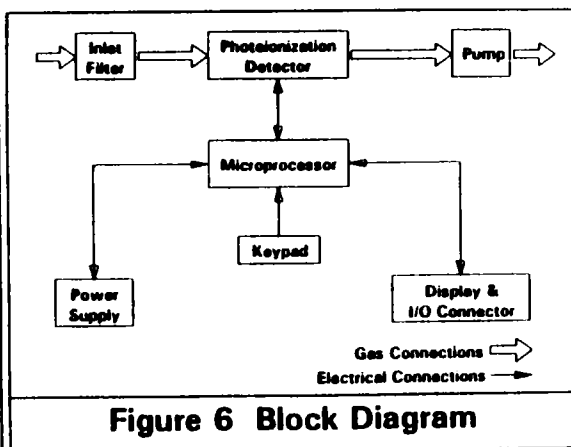
Use a printer to test both MicroTIP and the computer. Connect MicroTIP to the printer and ensure that this arrangement produces the desired results. If correct printout is obtained then the MicroTIP and the printer cable are okay.

Now connect the computer to the printer and ensure this works. If the desired printout is obtained this ensures the computer is sending data correctly.

## Chapter 6 Technical Description

### 6.1 OVERVIEW

MicroTIP is a microprocessor controlled instrument for measuring the presence of photoionizable chemicals in air at parts per million levels. The block diagram in Figure 6 shows the main components of MicroTIP. The microprocessor controls the components of the instrument and interprets and records the signal generated by the photoionization detector (PID). Recorded data and setup information entered into the microprocessor's memory are retained when MicroTIP is turned off.



**Figure 6 Block Diagram**

A pump continuously pulls the air under test through MicroTIP's PID. The PID converts the concentration of ionizable chemicals in a sample into an electrical signal. The microprocessor subtracts any background from the signal and divides this signal by a sensitivity previously obtained by calibrating with a standard gas of known concentration. This concentration appears on MicroTIP's display and, depending on the values entered through MicroTIP's keypad, an alarm message may be displayed or an audio signal may be heard.

MicroTIP can detect thousands of different types of airborne

gases and vapors and its response depends on the type as well as the concentration. MicroTIP does not distinguish one type of chemical from another, but displays a number indicating the total concentration of all photoionizable compounds in the sample.

A standard of isobutylene at a known concentration may be used for setting the sensitivity. If MicroTIP is calibrated with isobutylene, it displays concentrations in units equivalent to ppm of isobutylene. If isobutylene were the only photoionizable chemical in the sample, then MicroTIP would display its concentration directly.

MicroTIP responds more or less readily to other chemicals than it does to isobutylene. Because it has a medium sensitivity to isobutylene, this gas has been chosen as a reliable means of reporting an average concentration of total ionizables present.

For special applications, gases other than isobutylene can be used to calibrate MicroTIP.

### 6.2 PHOTOIONIZATION DETECTOR

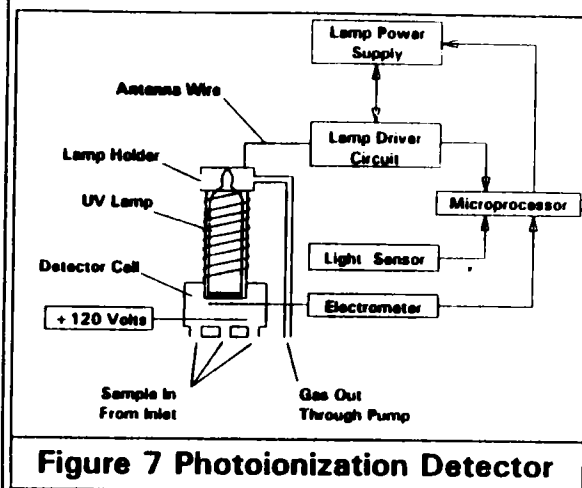
MicroTIP's PID is shown in Figure 7. The PID measures the concentration of photoionizable chemicals in the gas stream from the sample inlet and produces an electrical signal for the microprocessor.

A UV lamp generates photons which ionize specific molecules in the gas stream. The permanent air gases (argon, carbon dioxide, nitrogen, oxygen, water vapor etc.) require a relatively high energy for ionization, and are not ionized by the UV photons. Many of the chemicals considered pollutants, including most hydrocarbons, are ionized.

The gas stream is directed into the PID through a small port at the center of the lamp window and through a series of larger ports around the perimeter of the lamp window. This bypass arrangement permits a high sample flowrate and short response time while minimizing contamination of the lamp window.

The ionized molecules in the detector cell are subjected to a continuous electric field between the repeller electrode and

## Chapter 6 Technical Description



the collector electrode. The ions move in the electric field, generating a current which is proportional to the concentration of the ionized molecules in the detector cell. An electrometer circuit converts the current to a voltage which is then fed to the microprocessor.

The detector lamp is operated by an HF lamp driver circuit which delivers high frequency energy to the lamp through an antenna wrapped around the lamp holder. The lamp driver power supply is controlled by the microprocessor based on a feedback signal from a light sensor on the HF driver circuit board.

### 6.3 CALIBRATION AND RECORDING

Periodic calibration is required to compensate for PID output changes due to inlet filter restriction, lamp window cleanliness, sample pump wear and other factors.

During calibration, MicroTIP's PID is first exposed to zero air. A small signal is generated. This zero signal is stored by the microprocessor.

In High Sensitivity operation, the microprocessor subtracts

## Chapter 6 Technical Description

the zero signal from the PID signal, and multiplies the difference by 1000. This number is then displayed.

When one of the 10 Cal Memories is selected, MicroTIP's PID is next exposed to span gas. This span signal is stored. The microprocessor subtracts the zero signal from the span signal and divides the difference by the user-entered span gas concentration. The resulting sensitivity is stored in the selected Cal Memory with the zero signal. In operation, the microprocessor first subtracts the zero signal from the PID signal, then divides the difference by the sensitivity. This number is then multiplied by the response factor and displayed.

The microprocessor accumulates all readings over a 15 second interval and determines the minimum, average and maximum readings. It stores these numbers along with the highest priority instrument status and the most recent time, date and Event number which occurred during the 15 second interval. MicroTIP automatically records these results for 12 hours of operation when the datalogger is turned on.

These recorded data can now be played back on MicroTIP's display. The display is identical to the numeric or bar graph display, but the instrument status is "Play" indicating that recorded data, not real-time data, are being displayed. During playback MicroTIP continues to analyze and record new data.

Recorded data can also be printed as either a table or a graph. Data may be automatically averaged to fit on one 8 1/2" x 11" page, or all recorded data may be printed or graphed. The averaging interval and number of readings averaged are shown at the top of the page.

For each averaging interval, MicroTIP prints the minimum of all the minima, the average of all the averages and the maximum of all the maxima.

## Chapter 7 Specifications

## Chapter 7 Specifications

Size:	43 cm (16.9") long, 9.5 cm (3.75") wide, 14.6 cm (5.75") high
Weight:	2.5 kg (5.5 lbs)
Detector:	Photoionization, bypass-type, with standard 10.6 eV HF-excited electrodeless discharge tube
Keypad:	16-key silicone with tactile feedback
Display:	2-line, 16-character dot-matrix, liquid crystal for alphanumeric and bar graph readouts
Datalogging memory:	25k
Chart recorder output:	0 to 1 volt full scale
Serial output:	RS-232, 300-19200 baud with odd, even or no parity, for tabular and graphic printouts
Audio output:	Continuous concentration-modulated tone or tone on alarm only
Inlet connection:	1/8" (3.2 mm) stainless steel compression fitting
Outlet connection:	1/8" (3.2 mm) stainless steel barb fitting
Battery type:	Sealed lead-acid, replaceable pack
Charge/discharge time:	8 hr/7 hr
Battery charger:	Automatically charges and maintains full charge in battery pack
Materials in sample stream:	Stainless steel, Teflon®, Viton®
Inlet filter:	Replaceable stainless steel, 2 µm
Inlet flowrate:	Exceeds 500 mL/min

## Chapter 7 Specifications

Operating temperature range:	0 to 40°C (32 to 105 °F)
Operating humidity range:	0 to 100% Relative Humidity (non condensing)
Operating concentration range:	0.1 to 2000 ppm isobutylene equivalent
Accuracy:	Isobutylene: (after calibration with Zero Air and 100 ppm isobutylene Span Gas): within $\pm 2$ ppm or $\pm 10\%$ for 0 to 100 ppm; within $\pm 10\%$ for 100 to 1000 ppm; within $\pm 15\%$ for 1000 to 2000 ppm  Acetone: (after calibration with Zero Air and 100 ppm acetone Span Gas): within $\pm 4$ ppm or $\pm 20\%$ for 0 to 100 ppm; within $\pm 30\%$ for 100 to 1000 ppm; within $\pm 30\%$ for 1000 to 2000 ppm  Benzene: (after calibration with Zero Air and 100 ppm benzene Span Gas): within $\pm 4$ ppm or $\pm 10\%$ for 0 to 100 ppm; within $\pm 20\%$ for 100 to 1000 ppm; within $\pm 25\%$ for 1000 to 2000 ppm  Toluene: (after calibration with Zero Air and 100 ppm toluene Span Gas): within $\pm 2$ ppm or $\pm 20\%$ for 0 to 100 ppm; within $\pm 30\%$ for 100 to 1000 ppm; within $\pm 30\%$ for 1000 to 2000 ppm  Trichloroethylene: (after calibration with Zero Air and 100 ppm trichloroethylene Span Gas): within $\pm 5$ ppm or $\pm 10\%$ for 0 to 100 ppm; within $\pm 25\%$ for 100 to 1000 ppm; within $\pm 45\%$ for 1000 to 2000 ppm
Precision:	$\pm 1\%$ (100 ppm isobutylene)
Response time:	Less than 3 seconds
Detection limit:	0.1 ppm isobutylene

## Chapter 8 Warranty

MicroTIP is warranted for one year against defects in materials and workmanship.

Photovac Incorporated warrants that its manufactured products (except Detector UV Lamps which carry specific warranties) will be free from defects in materials and workmanship for a period of one (1) year from the date of receipt by the Customer. This Warranty applies to proper use of the equipment by the customer and may be voided if, in the opinion of Photovac Incorporated, the product has been abused or treated in a negligent manner so as to cause damage or failure. Negligent use includes, but is not limited to, exposure of the internal parts of the equipment to water. Damage caused thereby is expressly excluded from this Warranty.

When Photovac is made aware of a problem in MicroTIP which would be eligible for remedy under Warranty, it will issue a Return Authorization Number to the Customer. No return will be accepted unless such authorization has been obtained.

If upon receipt of the equipment Photovac determines that repairs should be done under Warranty, Photovac's sole liability shall be for labor and materials necessary to put the equipment into proper order and return this to the Customer as promptly as possible. Photovac is in no way responsible for any inconvenience or loss, consequential or incidental, caused to the Customer as a result of the equipment being out of commission.

The Customer is responsible for shipping and insurance to the designated Photovac Service/Repair facility.

**In USA:**  
Photovac International  
Incorporated  
25-B Jefryn Boulevard West  
Deer Park, New York, 11729  
(516)254-4283

**In Canada:**  
Photovac Incorporated  
105 Doncaster Avenue  
Thornhill, Ontario  
L3T 1L6  
(416)881-8225

Outside USA and Canada: Contact the Photovac representative in your area.

## Appendices

### APPENDIX A - INSTALLING AC PLUG

The MicroTIP battery charger is supplied with a grounded North American plug for 100-130 VAC operation. For use in other countries it must be replaced with a suitable plug.

1. Cut the power cord near North American style plug
2. Separate and strip the two wires.
3. Connect one wire to the neutral terminal of the new plug. Connect the other wire to the live terminal of the new plug and assemble the new plug.
4. Set the voltage selection switch, on the bottom of the battery charger, to the correct voltage.

Warning: Incorrect AC connection can be lethal. Photovac cannot be responsible for errors in connection.

### APPENDIX B - SPAN GAS SUPPLIER

The MicroTIP Calibration Kit includes the following items:

1. Gas pressure regulator with contents gauge, to fit a 6D size cylinder of span gas
2. Gas sampling bag
3. Adapter tubing with fittings for regulator and MicroTIP inlet (attached to gas bag).

The kit does not include a tank of span gas. The recommended span gas, isobutylene at 100ppm + / 5% in air, may be obtained from:

Alphagaz Specialty Gases Division  
Liquid Air Corporation  
P. O. Box 149, Woods Road  
Cambridge, MD 21613, USA

Telephone: (301)228-6400

Outside the US contact the Alphagaz office above for the nearest location.

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[illegible]

**Recorder Paper (in recorder)**

R-5L	5-Liter Tedlar Bag . . . . .	bags	_____
R-SGCH	Methane Span Gas . . . . .	cylinders	_____
R-TY	Tygon Tubing . . . . .	feet	_____
C1059	Recorder Paper for 128 . . . . .	rolls	_____
R-DL	Diluter Kit (10:1) . . . . .	each	_____

**Special Instructions:**

**Receiving Tech**

white - inbound file • yellow - inbound customer • pink - outbound file • gold - outbound customer

[illegible]

### Purchased Support Accessories

R-5L	5-Liter Tedlar Bag . . . . .	bags	_____
R-SGCH	Methane Span Gas . . . . .	cylinders	_____
R-TY	Tygon Tubing . . . . .	feet	_____
C1059	Recorder Paper for 128 . . . . .	rolls	_____
R-DL	Diluter Kit (10:l) . . . . .	each	_____

QC Operational Check: YMA \_\_\_\_\_  
QC Cal Check: YMA \_\_\_\_\_

Special Instructions: \_\_\_\_\_

QC / QA Tech MAJ  
Shipping Tech MAJ  
Receiving Tech \_\_\_\_\_

**1-800-332-0435**

white - inbound file • yellow - inbound customer • pink - outbound file • gold - outbound customer

# Modèle MX251

Indicateur de gaz combustibles et d'oxygène

Livret d'instructions

**INDUSTRIAL  
SCIENTIFIC**



1001 Oakdale Road  
Oakdale, PA 15071

Pour les Etats-Unis et le Canada:  
Appeler sans frais le 1-800-DETECTS (338-3287)  
ou le (412) 788-4353

1707 364

**INDUSTRIAL  
SCIENTIFIC**

## Model MX251

Combustible Gas and Oxygen Monitor

### Instruction Manual



1001 Oakdale Road  
Oakdale, PA 15071

Call Toll Free: 1-800-DETECTS (338-3287)  
U.S.A. and Canada  
or (412) 788-4353

1703-7664

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## 1.0 GENERAL INFORMATION

### 1.1 Air and Gases

Air is a mixture of gases. Clean, dry air consists of 78.08 volume percent nitrogen, 20.95 volume percent oxygen, and 0.87 volume percent other gases including argon and carbon dioxide. Life, combustion and various chemical reactions are supported by oxygen. Human beings can tolerate moderate variations in the amount of oxygen in the air. Breathing becomes labored when the air contains only 16% oxygen. However, U.S. Department of Labor-OSHA (General Industry Safety and Health Standards 29 CFR 1910.94 (d) (9) (vi) requires the use of air-supplied respirators to provide adequate oxygen when the concentration of oxygen is less than 19.5%. Oxygen deficiency can be

the result of the displacement of oxygen by other gases, aerobic bacterial activity, combustion, and the oxidation of metal.

A mixture of air and a combustible gas or vapor (hereinafter the term "gas" shall be understood to mean combustible gases and/or vapors) will support the propagation of a flame away from a source of ignition only when the concentration of the gas, as a percent of the total volume of the mixture, is within the flammable range of that specific gas or combination of gases. An air/gas mixture in which the concentration of gas is below the flammable range will be too lean to propagate combustion. The flammable range has a lower limit and an upper limit; i.e., the lower flammable limit (LFL) and "lower explosive limit" (LEL) are equivalent, as are "upper flammable limit" and "upper explosive limit".

### 1.2 Warnings and Cautionary Statements

Certain conditions or failure to observe certain necessary procedures will impair the performance of the instrument. These are outlined below to be read and understood by any person using the instrument.

1.2.1 Oxygen deficient atmospheres will cause erroneous low determinations of the combustible gas content of the air.

1.2.2 Oxygen enriched atmospheres will cause erroneous high determinations of the combustible gas content of the air.

1.2.3 Verify the calibration of the combustible detecting mode of the instrument after use where the combustible gas content as a percent of the LEL was 100% or greater. Long continuous use (hours for one test) at high LEL concentrations (50% to 100%) may cause

damage to the LEL detector, resulting in reduction of sensitivity and erratic behavior, including inability to calibrate. If this occurs, the LEL detector should be replaced.

**1.2.4** Silicone compound vapors and sulfur compound vapors will cause desensitization of the LEL detector and thus cause erroneous low determinations. Verify the calibration of an instrument that has been used where these vapors were present before that instrument is relied upon for accurate measurements. Replace the LEL detector if the instrument cannot be calibrated.

**1.2.5** Changes in the total pressure of the atmosphere due to changes in altitude will bear on the instrument's determination of the air's oxygen content. Calibrate the oxygen monitor mode of the MX251 at the altitude at which it will be used.

**1.2.6** Any rapid up-scale reading followed by a declining or erratic reading, or reading greater than 100% LEL, may indicate a gas concentration beyond the accurate response range of the LEL detector. Either take immediate corrective action to eliminate this potential hazard; or, withdraw from it.

**1.2.7** Readings that are either negative or greater than 100% LEL may indicate an explosive concentration of combustible gas.

**1.2.8** Obstruction of the screened sensor ports will cause erroneous low readings. These screens must be kept clean.

**1.2.9** Sudden changes in temperature or pressure may cause temporary fluctuations in the oxygen reading.

**1.2.10** Alarm device is nonlatching and will automatically reset.

## 2.0 INTRODUCTION

The MX251 Monitor continuously and simultaneously monitors ambient levels of oxygen and combustible gases. Both gases are monitored simultaneously; only one is displayed on the instrument's liquid crystal display (LCD). When one of two membrane switches located immediately below the LCD panel is touched, the respective gas readout will appear on the display. A small triangular pointer also appears on the display, just above the switch that was pressed, to indicate which gas is being displayed. The last gas selected will remain on display until a different switch is pressed. When the instrument is first turned on it will automatically display the oxygen readout. (See figure 1).

Although only one gas can be displayed at a time, both alarm circuits are active and continuously monitoring for unsafe conditions. If either of the gases reaches a preset safety limit, the audible and visual alarms are activated immediately. The audible alarm is a high pitched tone that alternates between two frequencies at the rate of approximately two times per second. A rectangular LCD enunciator appears near the top of the display panel to indicate which gas or gases caused alarm activation. The LCD will continue to display the readout of the gas range last selected by touching one of the membrane switches. (See figure 2).

Combustible gases are displayed in percent of lower explosive limit (LEL) in 1% LEL increments and oxygen (OX) in percent by volume in 0.1% increments.

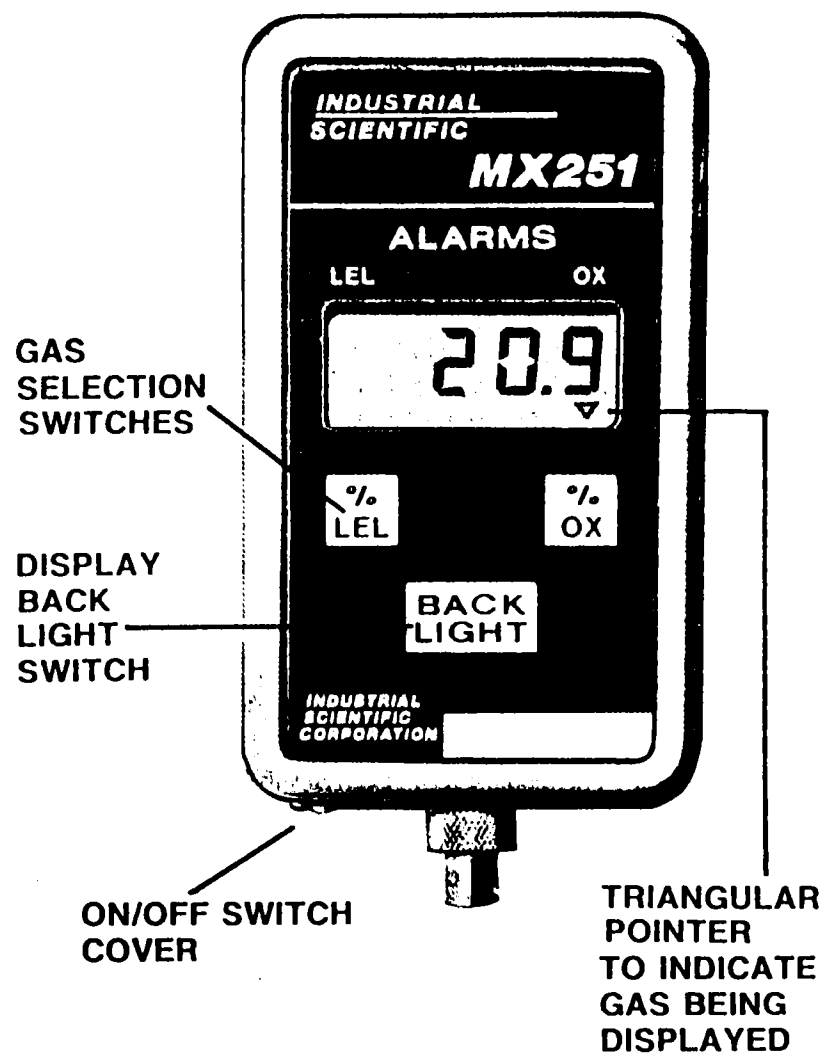
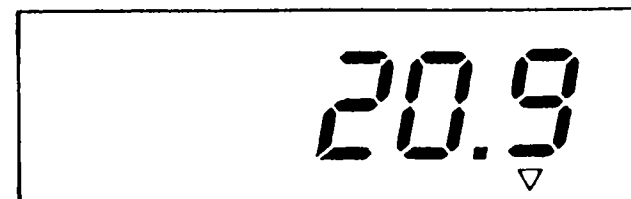
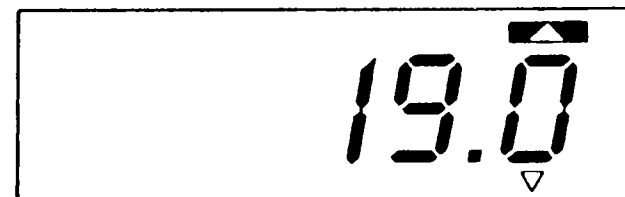


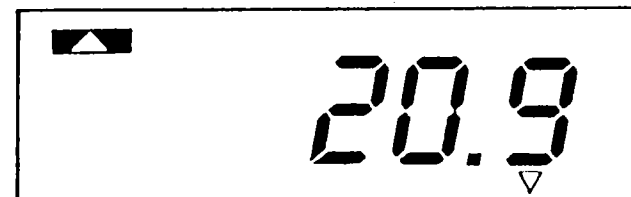
Figure 1.  
MX251 Controls



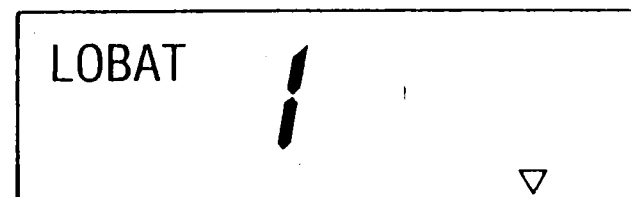
NORMAL OPERATION



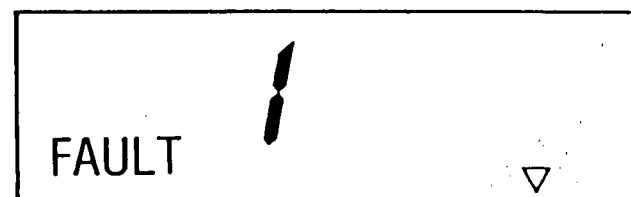
UNSAFE OXYGEN LEVEL



NORMAL OXYGEN LEVEL DISPLAYED  
COMBUSTIBLE GASES IN ALARM MODE



BATTERY FAILURE



SENSOR FAULT

Figure 2.  
Display and Alarms

Although primarily intended as a diffusion instrument, the monitor can be equipped for remote monitoring with an optional sampling pump.

### 3.0 UNPACKING

The shipping case should contain the following items. Account for each item.

**TABLE I. PACKING LIST**

QTY.	PART NO.	DESCRIPTION
1	1810-1527	MX251 (Nicaid) Combustible Gases and Oxygen Monitor
1	1810-1550	MX251 (Alkaline) Combustible Gases and Oxygen Monitor
1	1703-7664	Model MX251 Instruction Manual
1	1700-6933	Calibration Cup
1	1700-7592	Tygon Tubing
1	1703-8803	Micro Screwdriver w/Hex Head

After unpacking, visually inspect each item for signs of physical damage. If damage is evident, contact either the local distributor of ISC detection instruments, or call Industrial Scientific at:

1-800-DETECTS (338-3287)  
U.S.A. and Canada  
or  
(412) 788-4353

## 4.0 BATTERIES

Before Proceeding to use the Instrument, Nicad Users are to Charge the Batteries and Calibrate the Unit. Alkaline Users need only to Calibrate the Instrument.

### 4.1 Charging the Batteries. (Nicad Users Only)

**Note:** Instrument must be turned off before charging.

The MX251 requires a constant 75 milliamperes charging current. A completely discharged battery's full potential will be restored by 14 hours of charging. A Single Unit Charger, Part Number 1810-0123, and a Five Unit Charger, Part Number 1810-0115, are available from the local distributor of Industrial Scientific Corporation products. There is no danger of overcharging the batteries when using either of the above ISC 200 Series Constant Current Battery Chargers.

Apparent reductions in battery capacity may result from repetitive use patterns. A fully charged battery that does not deliver energy for at least 10 hours continuous monitoring may have developed a "memory" condition. To eradicate this, entirely discharge the battery (until low battery warning) and then fully recharge the battery. The memory effect can be avoided by using the MX251 so that the battery is discharged to varying depths.

The MX251 Nicad Unit is powered by a 750 milliamp/hour (mah) rechargeable nickel cadmium battery pack. When charged for 14 hours on any of the ISC charging units, the battery will power the monitor for a minimum of 10 hours. Typical run time will be approximately 12 hours.

## 4.2 Alkaline Batteries

The MX251 Alkaline Unit is powered by (4) disposable size AAA alkaline batteries. The instrument is factory shipped with batteries installed.

A set of new batteries will deliver power for at least 8 hours of continuous monitoring at normal room temperature. Actual run time will vary between battery makes. When the temperature is near or below freezing, the operating time will be reduced significantly. This is a characteristic of alkaline batteries.

**Note:** Use only Industrial Scientific Corporation Part No. 1703-4265 or one of the approved battery types listed on the instrument. Always replace all four batteries at the same time.

The battery cover is held in place with a quarter turn fastener. Remove the battery cover by inserting flat blade screwdriver in the fastener slot and turn the fastener one-fourth of a turn in the counter clockwise direction. First, remove batteries from positions 2 and 3. Then, move the batteries from positions 1 and 4 to positions 2 and 3 for removal.

To insert new batteries, the instrument should be positioned face down. Insert the battery for position 1 into the instrument at position 2. Then, move it to position 1. Insert the position 2 battery. Insert the battery for position 4 into the instrument at position 3. Then, move it to position 4. Insert the position 3 battery. Check the exposed battery terminals against the battery cover markings for proper alignment before installing the battery cover. Press the battery cover into position and secure by turning the fastener one-fourth of a turn in the clockwise direction. (See figure 4.)

## 4.3 Battery Discharge (Nicad & Alkaline Users)

When the battery pack is almost fully discharged (approximately ½ hour of operating time remaining), the monitor will start to emit short audible tone bursts to warn of a low battery pack condition. The tone bursts are about one to five seconds in duration and two to three minutes apart. The duration increases in length until the batteries are no longer capable of supplying sufficient power. Then, the monitor will go into the battery failure mode. The battery failure mode is indicated by all of the display digits being blanked except for the numeral (1) at the far left position; the word LOBAT appears in the upper left corner of the display; and the audible alarm sounds a continuous tone. (See Figure 2.) The above condition will continue for approximately 10 minutes or until the monitor is switched off. When battery pack fail mode occurs, Nicad Users must recharge the battery pack for at least 14 hours; Alkaline Users must replace the batteries with a new set.

**Note:** After the monitor goes into the battery failure, it should be switched off within a few minutes. If the unit is not switched off within 10 minutes, inaccurate fluctuating readings will appear on the display and serious battery damage may result to Nicad Users.

The MX251 is also equipped with circuitry that detects LEL sensor faults. If a fault condition should occur, the monitor will go into a failure mode similar to the low battery failure mode and the word FAULT will appear in the lower left corner of the display. When the oxygen sensor is missing, audible and visual alarms are activated. (See figure 2.)

## 5.0 PREPARING FOR OPERATION

### 5.1 Switching ON the instrument (see Figure 3)

To switch on the instrument:

1. Back off the knurled nut that holds the calibration cover in place.
2. Rotate the cover so that the metal button is inserted in the oval-shaped hole.
3. Tighten the nut until the calibration cover is flush with the case. Do not overtighten.

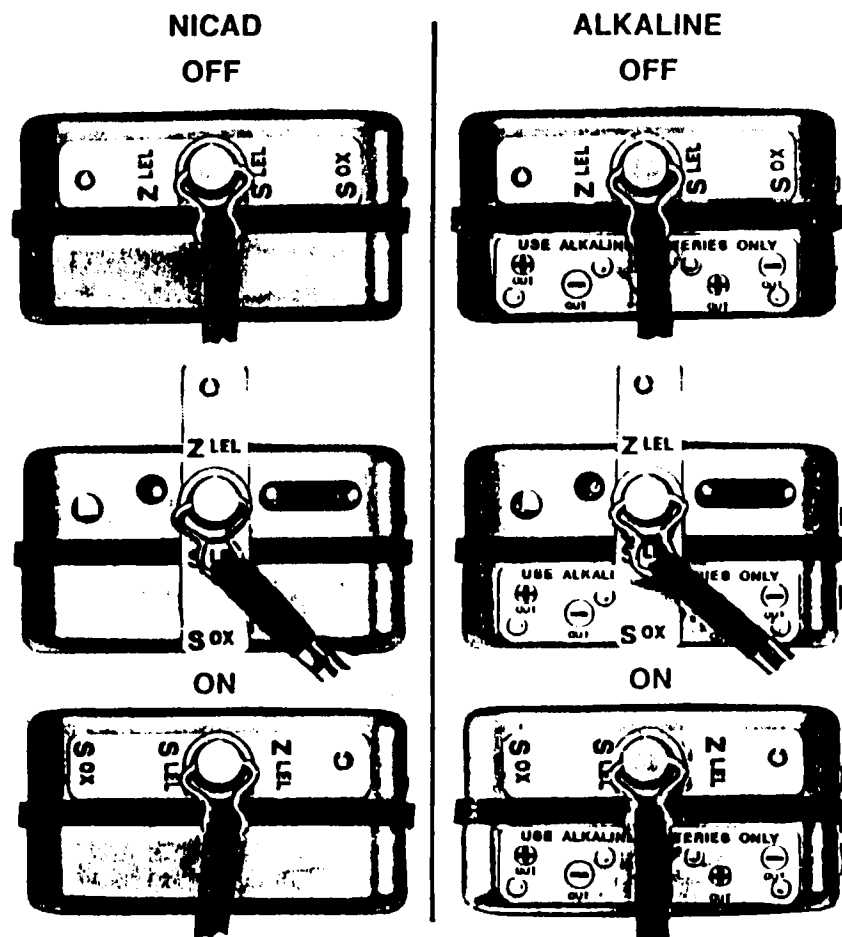


Figure 3.  
Instrument ON/OFF

4. The monitor is ready for use as soon as the display stabilizes (approximately 60 seconds).

## 5.2 Switching OFF the instrument (see Figure 3)

To switch off the instrument:

1. Back off the knurled nut that holds the calibration cover in place.
2. Rotate the cover so that the metal button is inserted in the unmarked round hole.
3. Tighten the nut until the calibration cover is flush with the case. Do not overtighten.

## 6.0 CALIBRATION

### 6.1 General Information

Maximum safety will be insured by performing a calibration check on the MX251 prior to each use. A calibration kit and replacement cylinders of calibration gas are available from ISC (See Table II).

For best calibration accuracy, the monitor should be allowed to stabilize at room temperature for at least one (1) hour before calibration.

TABLE II. CALIBRATION EQUIPMENT

Part No.	Description
1810-1261	Calibration kit, consisting of: Carrying Case 2 Cylinders of Pentane Regulator Calibration Cup
1810-1162	Replacement cylinder of Pentane

## 6.2 Checking Alarm Settings

Before calibrating the instrument, it is good practice to check all of the alarm settings to verify that they are set correctly. The calibration cover must first be released and turned ninety degrees to expose the three calibration adjustments along the bottom end of the instrument. The function of the three control adjustments are: (1) LEL zero offset Z LEL, (2) LEL span sensitivity S LEL, (3) OX calibration S OX. (See figure 4).

### 6.2.1 To Check LEL

To check the LEL alarm setting, switch the display to the LEL mode. Slowly turn the Z LEL (LEL zero offset) adjustment in the clockwise direction until the alarm is activated. When the alarm point is reached, slowly turn the adjustment back and forth through the point at which the alarm is activated. Observe the display. The display will show the percent of LEL at which the alarm is set to activate. Turn the adjustment back to the zero display reading. The factory setting for the LEL alarm is 10%.

### 6.2.2 To Check OX

Unlike the LEL, the OX section does not require a Z adjustment. After switching to the OX mode, observe and note the display reading, which should be 20.9% in normal room air. Slowly turn the S OX (OX calibration) adjustment counterclockwise until the low oxygen alarm setting is reached. Slowly turn the adjustment back and forth through the alarm point to verify the setting. After the low alarm setting is located, slowly turn the adjustment in the clockwise direction until the high oxygen alarm setting is found. Slowly turn the adjustment back and forth through the alarm point to verify the setting. Return the display to the original

setting. The oxygen alarms are factory set at 19.5% for the low alarm and 23.0% for the high alarm.

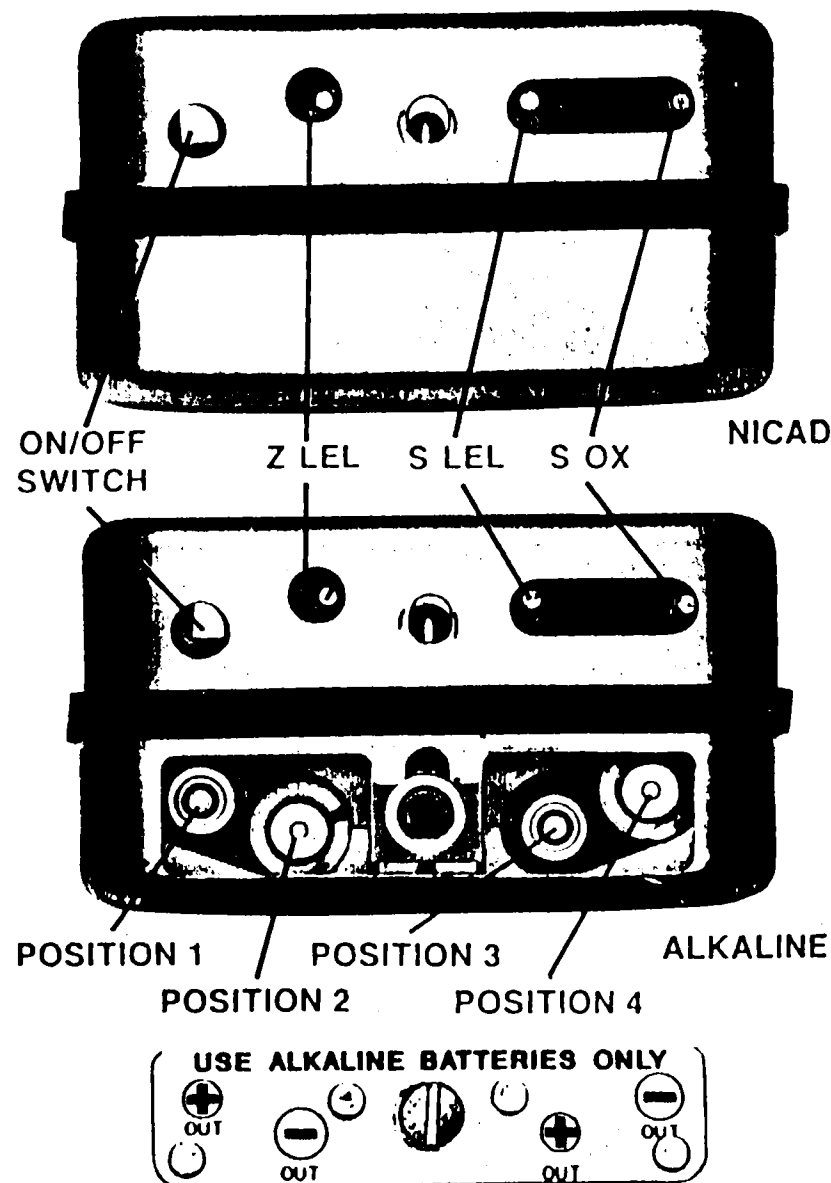


Figure 4.  
Calibration Adjustments and Batteries

## 6.3 Adjusting the Alarm Settings

In order to access the three alarm adjustments on the MX251, the instrument must be opened by separating the two halves of the case:

To open the case:

1. Use the 5/64" Allen wrench to remove the screws on either side of the monitor.
2. Back off the knurled nut of the strap assembly as far as possible. Use a 5/16" wrench to remove the center post of the strap assembly.
3. Lift the case top off the monitor. Set the case top (containing the electronics) aside, being careful not to damage the wires between the case top and bottom.
4. The alarm adjustments are located along the top end of the main printed circuit board and are identified with a label. (See figure 6).

### 6.3.1 Adjusting the LEL Alarm

Switch the display to the LEL mode and turn the Z LEL (LEL zero offset) adjustment, so that the display shows the desired level of LEL to which the alarm is to be adjusted. If the alarm is activated, the new LEL alarm is higher than the one currently set. Turn the LEL alarm adjustment, in the clockwise direction until the alarm is deactivated. Then, slowly turn the LEL alarm adjustment in the counterclockwise direction until the point is reached that again activates the alarm. The Z LEL adjustment should then be turned slowly back and forth through the alarm trip point to verify that it is correct. Return the display to zero.

### 6.3.2 Adjusting the OX Alarm

After the display has been set to the OX mode, use the S OX (OX calibration) control to set the desired level of the low oxygen alarm on the display. If the alarm is activated, the present setting is higher than the desired new setting. Turn the low alarm adjustment, in the counterclockwise direction until the alarm is deactivated. Now, turn the low alarm adjustment slowly clockwise until the alarm is once again activated. Slowly turn the S OX calibration control back and forth through the alarm point to verify the setting. Adjust the S OX calibration control so that the display reads the desired level for the high oxygen alarm. If the alarm is activated, the current setting is lower than the desired new setting. Turn the high alarm adjustment, in the clockwise direction until the alarm is deactivated. Now, turn the high alarm adjustment slowly in the counterclockwise direction until the alarm is once again activated. Turn the S OX calibration control back and forth through the alarm point to verify the setting. Return the display to its original setting.

**Note:** It is possible to overlap the high and lower oxygen alarm settings. If this happens, the alarm will be activated for all oxygen levels. To exit this condition, turn the high oxygen alarm to its highest clockwise position and the low oxygen alarm to its lowest counterclockwise position and repeat procedure 6.3.2.

Reassemble the monitor and perform calibration of both gases.

## 7.0 ZERO ADJUSTMENT

In clean air, switch the display to the LEL mode and adjust the Z LEL (LEL zero offset) control by turning it counterclockwise until the minus sign (–) appears on the display. Very slowly turn the Z LEL control clockwise until the minus sign just goes off, leaving (000) in the display.



Figure 5.  
Calibration Cup

## 8.0 SPAN ADJUSTMENTS

After the LEL zero has been properly set, the span sensitivity may be calibrated. Switch the display to the LEL mode, and apply the span gas of 25% LEL Pentane (see note 1) to the monitor using the calibration cup. Allow the gas to flow for two (2) minutes. With the gas still flowing, adjust the S LEL (LEL span sensitivity) control, on the bottom of the instrument, so that the display reads the percent of LEL, to the nearest percent, that is printed on the calibration gas cylinder. Remove the calibration gas.

In clean air, known to have 20.9% oxygen, the S OX (OX calibration) control should be adjusted so that the display reads 20.9% oxygen. Final calibration of the oxygen readout should only be done in free air if the user is sure that the air contains the normal 20.9% oxygen. The readout should then be adjusted so that the display reads 20.9%. If there is any doubt of the oxygen content of the air, calibration gas of a known percentage of oxygen in nitrogen should be used.

### Note 1

Industrial Scientific Corporation recommends that the calibration gas used for general combustible gas measurement is 25% LEL pentane. If you are measuring a known combustible gas, span calibration should be made using a known % LEL concentration of that gas.

## 9.0 MAINTENANCE

### 9.1 LEL Screen Replacement

A stainless steel screen protects the LEL sensor from direct impact and dust particles.

To remove the LEL screen:

1. Remove the four (4) screws that hold the bezel and screen in place.

Forced air cleaning may not remove very fine dust particles clogging the screen. NEVER use any type of solvent to clean the screen, since it may degrade sensor performance. A screen that cannot be cleaned should be replaced. See replacement parts list.

3. Reassemble the screen and bezel to the monitor.

## 9.2 Alarm Buzzer Screen Replacement

A stainless steel screen protects the alarm buzzer from direct impact and dust particles.

To remove Buzzer Screen:

1. Remove the four (4) screws that hold the Bezel and screen in place.
2. Open the Case per instructions in Section 6.3.
3. Remove the Alarm P.C. Board from the Case Bottom.
4. If the screen can not be cleaned while attached to the Buzzer Gasket, then the gasket and screen must be replaced. See replacement parts list.
5. Secure the Alarm P.C. Board to the Case Bottom. Reassemble the Case while being certain to dress the wire harness to fold into the center of the Case.
6. Resecure the Bezel to the instrument. Check to be certain that the LEL screen is in place prior to resecuring the Bezel.

## 9.3 Battery Pack Replacement: (Nicad Units)

Since it is normal for gas detection sensors and batteries to deteriorate with age, the MX251 has been designed so that it is possible to replace all of the sensors and the battery using only simple hand tools. No soldering is required. In all cases, it is necessary to

separate the two case halves. Always handle the opened instrument carefully to prevent damage to the wiring harness. The top half of the case should be flipped over and allowed to lay face down next to the bottom half of the case.

To replace the battery, first locate the battery wires that lead to a small two (2) terminal connector located at the far left end of the regulator printed circuit (PC) board. (See figure 6). Carefully pull the connector from the PC board and lift the battery from the case. It may be necessary to gently pry the battery free with a small screwdriver or similar object. Install the new battery in reverse order and carefully lay the battery leads down against the regulator PC board before reassembling the case halves.

## 9.4 Oxygen Sensor Replacement

Replacement of the sensors requires that the bezel and screens be removed first. This should be done prior to separating the case halves.

**Note:** Before replacing the sensors, pull the battery connector off to remove power.

To replace the oxygen sensor, first locate the small black connector in the sensor leads and carefully pull the two halves apart. Locate and remove the two long #2 screws that go through the front of the case bottom and into the oxygen sensor retaining bracket. Lift the oxygen sensor and bracket out of the instrument. When the sensor is removed, the plastic mounting ring may adhere to the sensor surface. The ring should be reinstalled in its original position. Next, install the new sensor in reverse order and reassemble the instrument.

**Note:** It is normal for the instrument to go into the high oxygen alarm immediately after a new oxygen sensor is installed. After the new sensor is connected to the instrument, it takes approximately ten minutes for the sensor to stabilize.

## 9.5 Combustible Gas Sensor Replacement

Locate the three circuit connector that connects the LEL sensor to the regulator PC board and disconnect it. (See figure 6). Locate and remove the two screws that mount the LEL sensor to the case bottom. Carefully remove the sensor from the case bottom. Install the new sensor in the reverse order. Make certain that the sealing gaskets are properly installed when mounting the new sensor. Reassemble the instrument in reverse order.

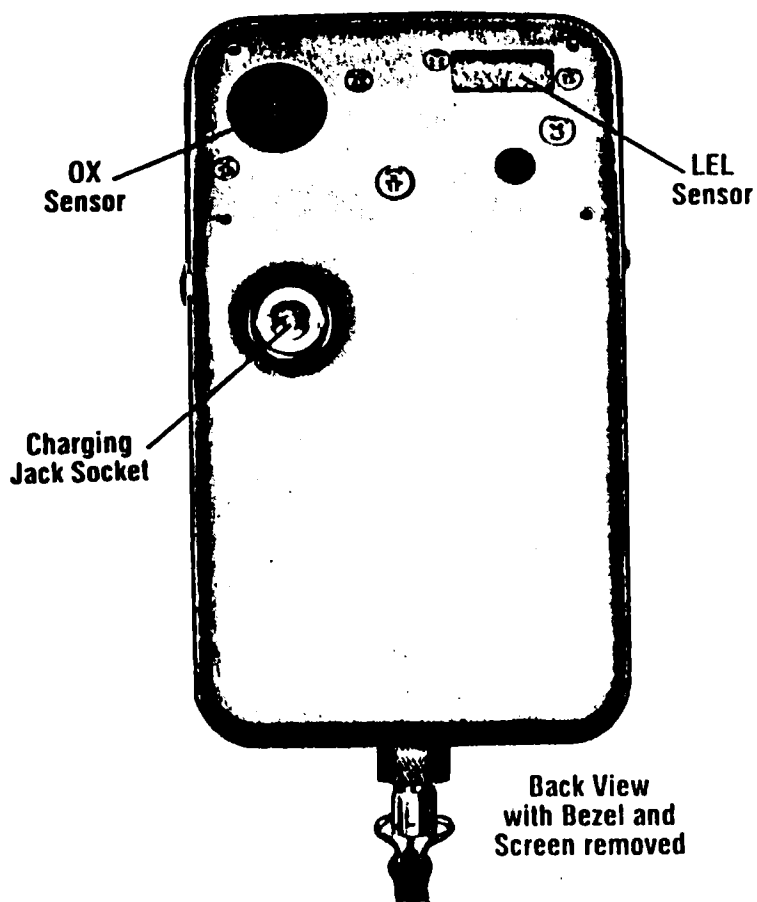
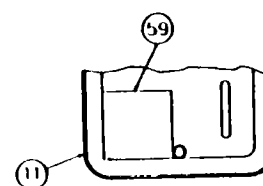
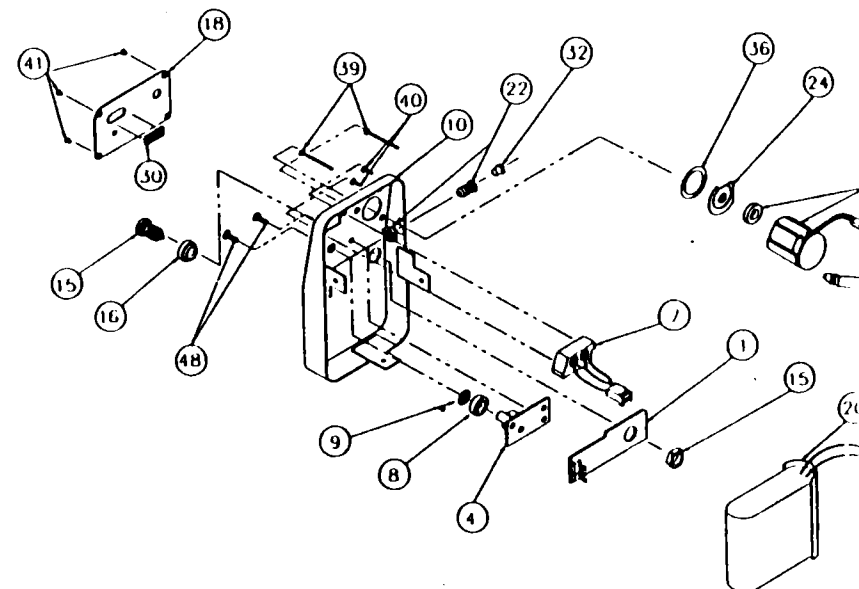
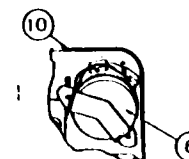


Figure 6.

(Continued on fold-out page.)



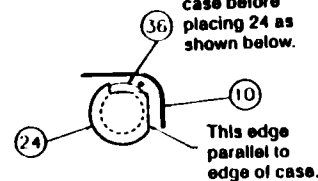
DETAIL C



DETAIL D

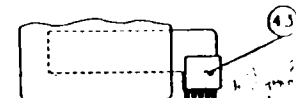
Assemble oxygen sensor with tabs located as shown. Route leads under clamp using caution so that the leads do not get pinched between the clamp and top of sensor.

Attach 36 to case before placing 24 as shown below.



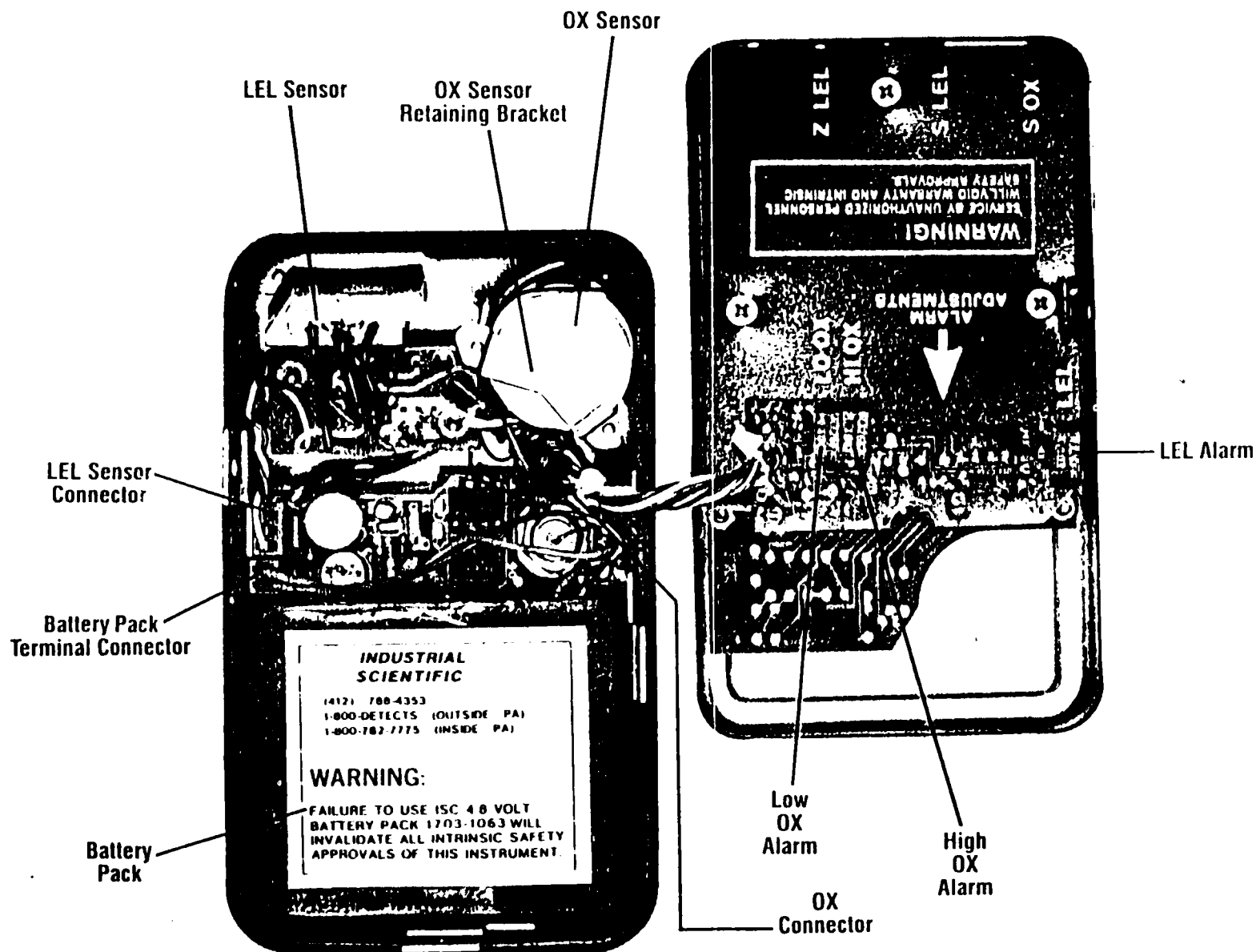
DETAIL E

This edge parallel to edge of case.



DETAIL F

Explo



**Figure 6.**  
**Battery Pack and Sensor Replacement (Nicad)**

(See page 27 for Alkaline Model)

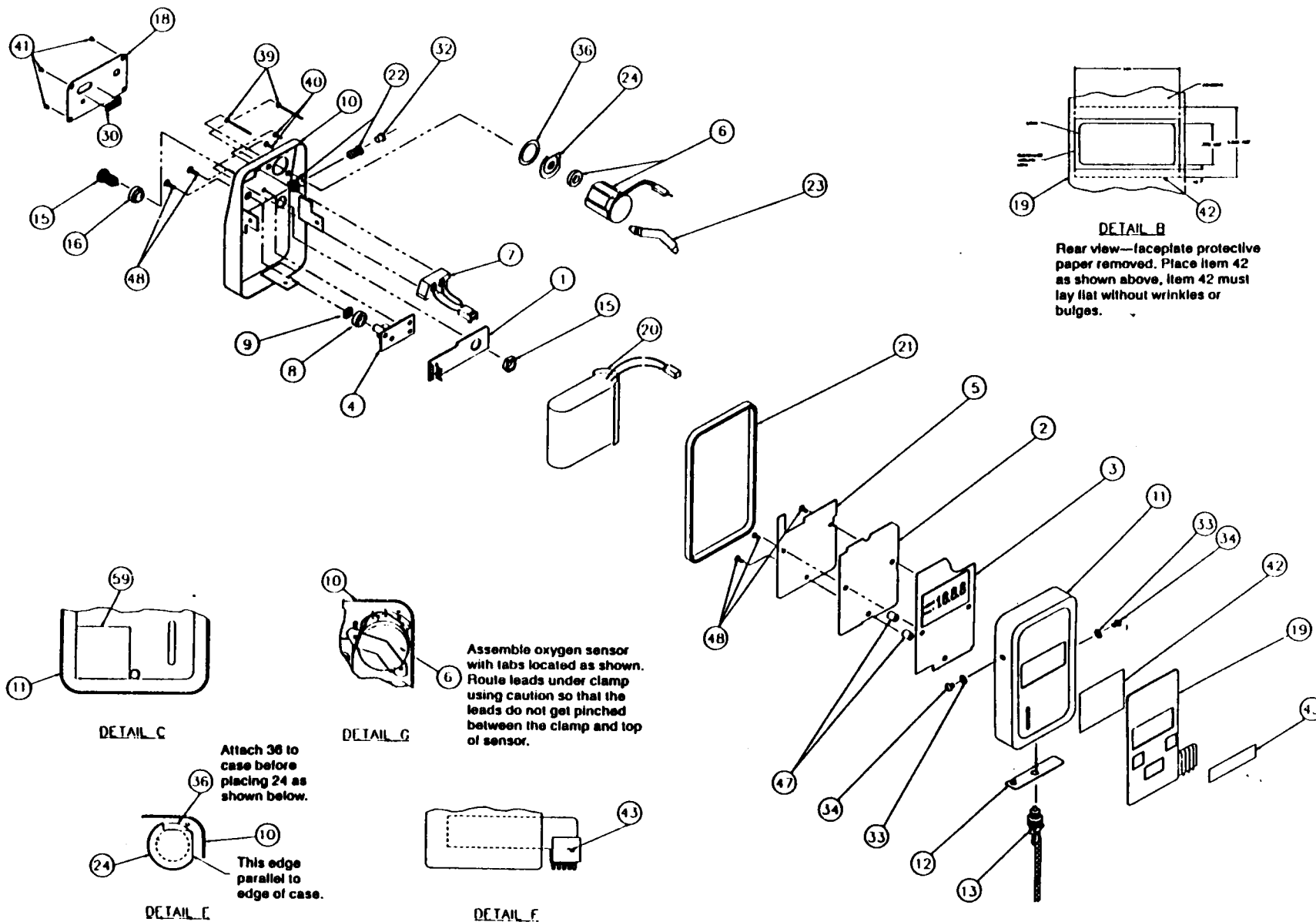


Figure 7.  
Exploded View (Nicad)

## 10.0 REPLACEMENT PARTS LIST (NICA)

Item numbers refer to Figure 7, Exploded View.

TABLE III. REPLACEMENT PARTS

Item	Part No.	Description
1	1703-1204	Board, P.C. Assy., 2.3V Reg.
2	1703-6351	Board, P.C. Assy., Main
3	1702-9018	Board, P.C. Assy., Display LEL
4	1703-6344	Board, P.C. Assy., Alarm
5	1703-6385	Insulator Assy.
6	1703-5114	Oxygen Sensor, Assy.
7	1703-1287	Detector, Assy., W/Conn.
8	1703-5767	Seal, Buzzer
9	1703-5775	Screen, Buzzer
10	1703-6187	Case, Bottom Assy.
11	1703-0081	Case, Top, Assy.
12	1703-6377	Calibration Cover Assy., LEL
13	1700-4078	Instrument Strap
15	1700-1660	Charging Jack Socket
16	1702-8630	Bushing, Chg. Jack
18	1703-6195	Bezel, 2-Gas
19	1703-6104	Panel, Membrane Switch
20	1703-1063	Battery Pack
21	1703-1782	Gasket
22	1702-8374	Receptacle
23	1703-1238	Clamp, O <sub>2</sub> Sensor
24	1703-2467	Cap, Sensor
26	1703-1527	Bead, Ferrite
30	1703-1345	Screen Detector LEL
32	1702-9273	Plug, Hole
33	1701-9787	Washer, LKG, #6
34	1701-3558	Screw, 6-32 x 3/16
36	1703-2475	Tape, Transfer
39	1702-8457	Screw, 2-56 x 1.00
40	1703-0693	Screw, 2-56 x .25
41	1701-7914	Screw, 2-56 x .12
42	1703-1618	Screen, Assy., Shield, RF

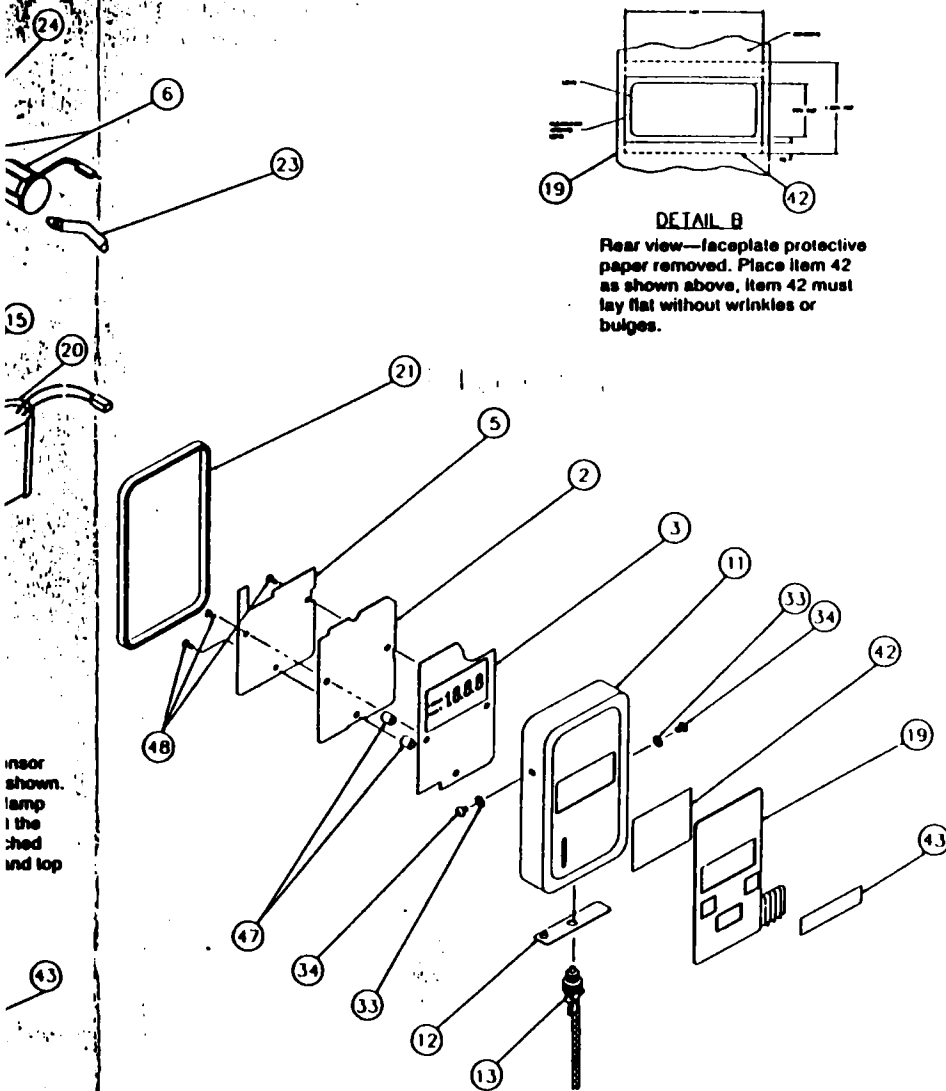


Figure 7.  
Exploded View (Nicad)

- \*44 1703-3234 Connector, Wired, Male
- 47 1703-1089 Spacer
- 48 1703-1774 Screw, #4-40 x .25
- \*57 1701-9753 Tie, Cable, Locking
- 59 1703-2020 Insulator

\*Item numbers refer to Figure 11, Wiring Diagram.



sensor  
is shown.  
clamp  
at the  
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and top



For your convenience and protection, record the serial number of your MX251 Monitor in the space provided.

Serial No. \_\_\_\_\_

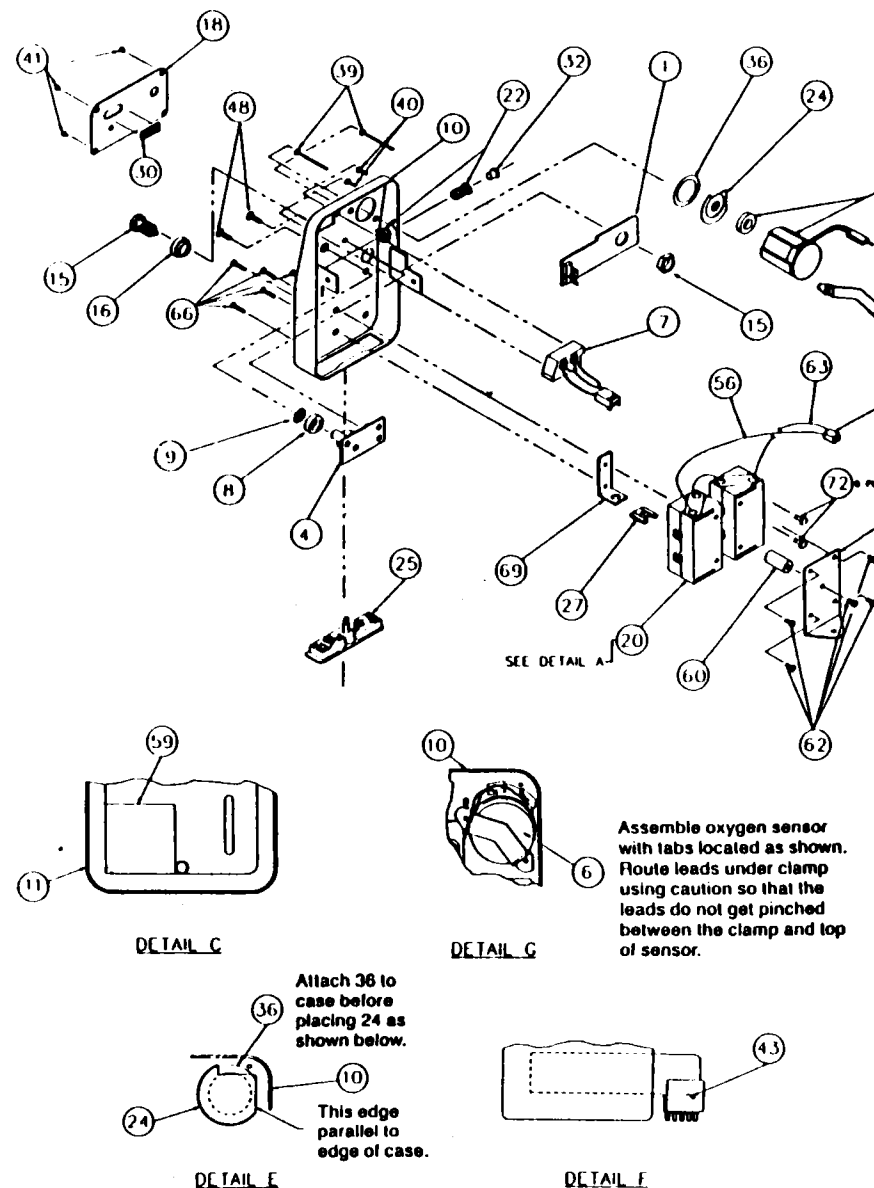


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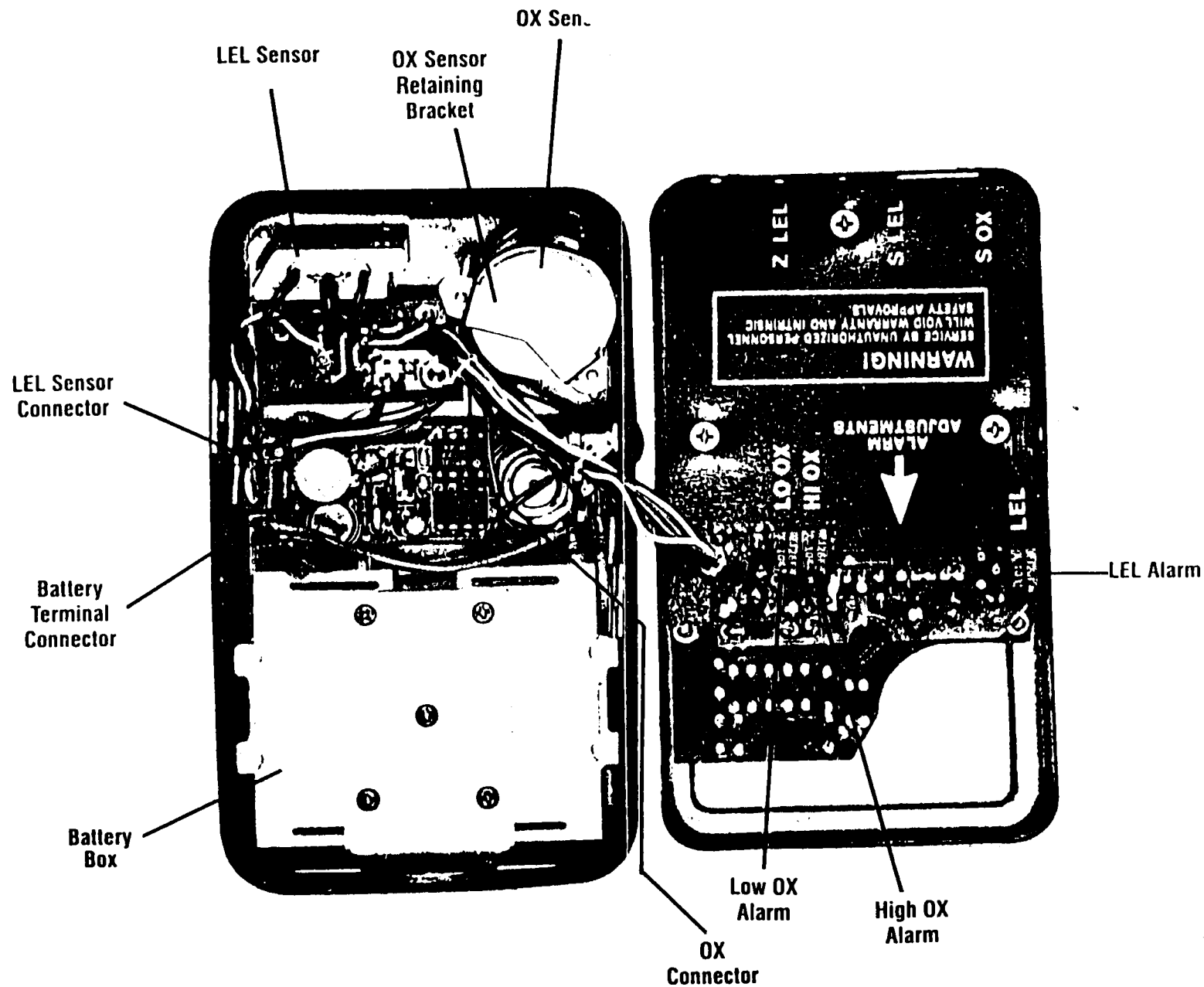


Figure 8.  
Batteries and Sensor Replacement (Alkaline)

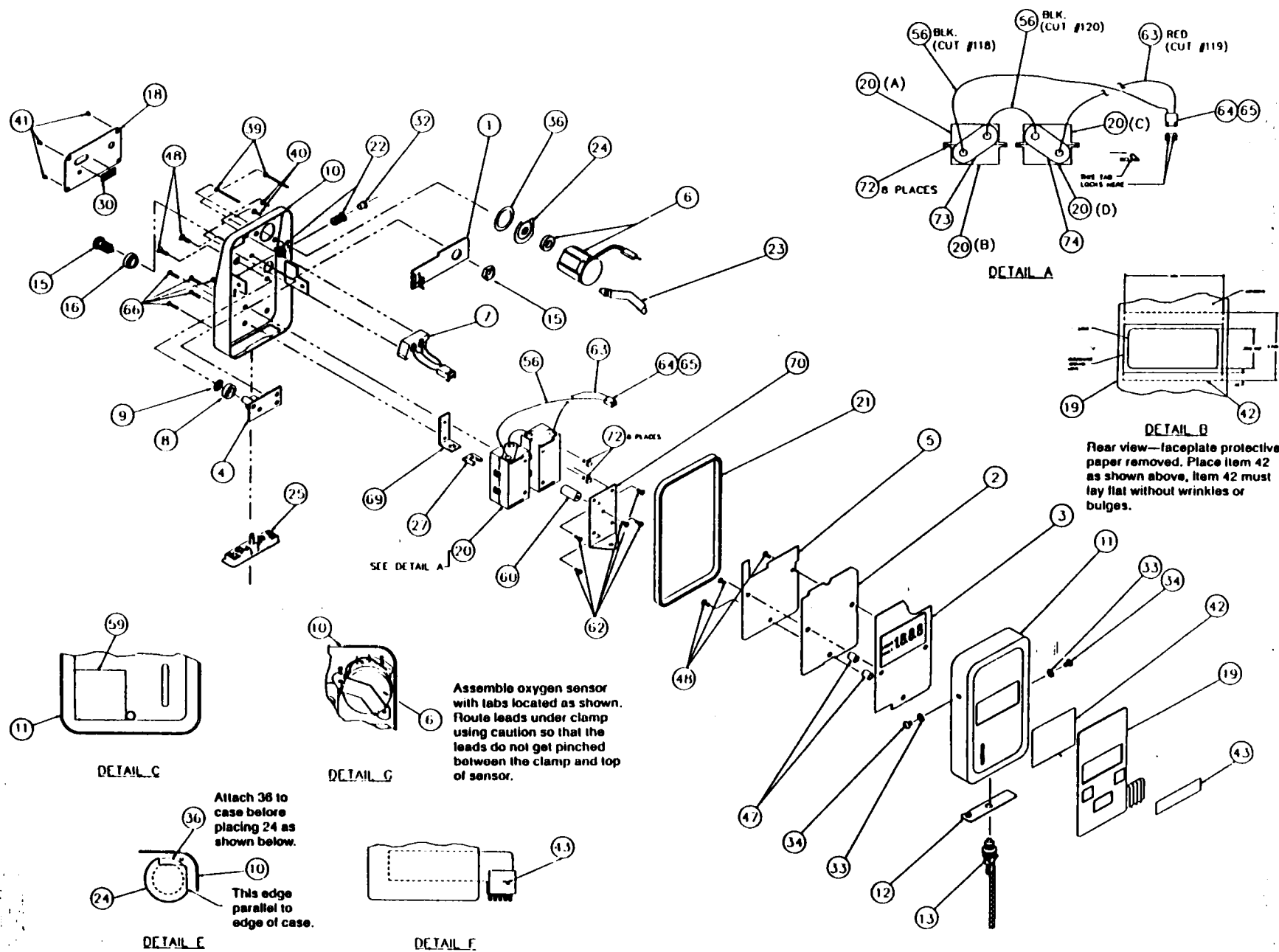


Figure 9.  
Exploded View (Alkaline)

42	/03-1618	Screen, Assy., Shield, RF
43	1703-1410	Tape
*44	1703-3234	Connector, Wired, Male
47	1703-1089	Spacer
48	1703-1774	Screw, #4-40 x .25
*57	1701-9753	Tie, Cable, Locking
59	1703-2020	Insulator
60	1703-6401	Spacer, Assy.
62	1703-4034	Screw, 2-56 x .18
63	1700-5323	Wire, PVC
64	1703-0388	Housing
65	1702-9351	Terminal
66	1703-2434	Screw, 2-56 x .187
69	1703-3523	Bracket, ¼ Turn
70	1703-3499	Bracket, Case
72	1703-4125	Pin, Snaplock
73	1703-4182	Battery Contact Assy., Left Hand
74	1703-4190	Battery Contact Assy., Right Hand
	1703-4265	Battery, AAA, Alkaline

\*Item numbers refer to Figure 11, Wiring Diagram.

For your convenience and protection, record the serial number of your MX251 Monitor in the space provided.

Serial No. \_\_\_\_\_

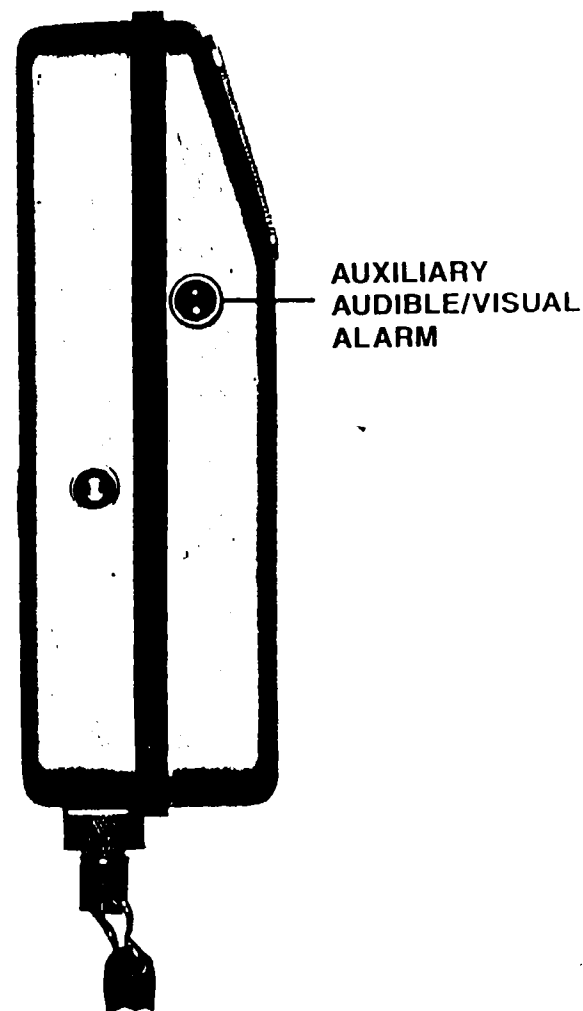


Figure 10.  
Side View

For those instances where a high noise environment is encountered, a jack is provided on the side of the MX251 case for use with the remote audible/visual alarm.



## 11. SPECIFICATIONS

### 11.1 Physical and Components

Case:	Stainless steel, dust tight, splash resistant
Dimensions:	4.75 x 2.75 x 1.5 inches (121 x 70 x 38 mm)
Weight:	20 ounces
Sensors:	Combustible Gases — Catalytic, Diffusion Type Oxygen — Electrochemical
Power Source:	Nicad—750 mA hour recharge- able, nickel cadmium battery pack Alkaline—Four AAA alkaline batteries
Battery Life:	Nicad—Minimum 10 hours per battery charge Alkaline—Minimum 8 hours at normal room temperature
Readout:	Digital liquid crystal display
Alarms:	Pulsing visual and audible alarms. Continuous visual and audible low battery alarms accompanied by display blanking. Expiring batter- ies indicated by a unique audible warning signal. Audible and visual alarms are activated when the oxy- gen sensor is missing. When the combustible gas sensor is open or missing, the fault condition will oc- cur, and the audible alarm will sound a continuous tone.

### 11.2 Performance

Measuring Range: Combustible Gases — 0 to 99%  
LEL

Oxygen — 0 to 30% of volume

### 11.3 Environmental Factors

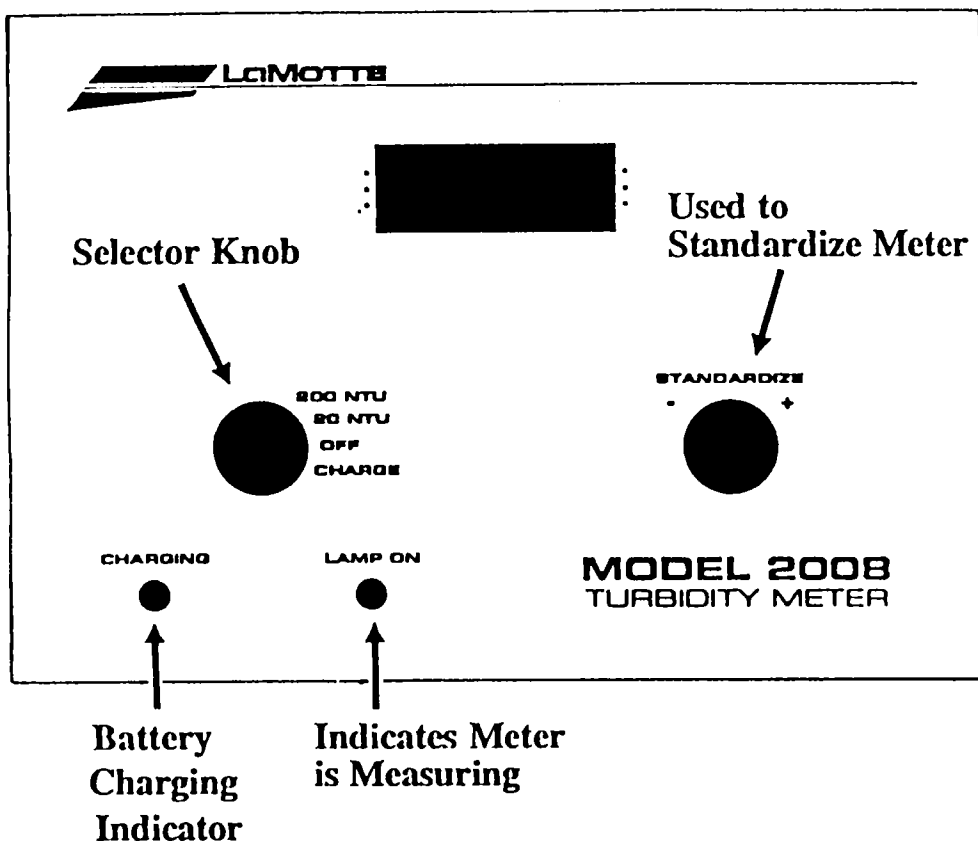
Temperature Range: -15°C to +45°C

Humidity Range: 0-95% RH (Noncondensing)



# **TURBIDITY MANUAL MODEL 2008**





The Model 2008 portable turbidimeter is acceptable for turbidity measurements reportable under either the National Primary Drinking Water Regulations (NPDWR) or the EPA's Surface Water Treatment compliance monitoring program. This instrument is suitable for testing municipal waters, food and beverage processing waters, and any aqueous solutions in which control of clarity is critical. The unit may be operated from line power via an AC adapter or from self-contained rechargeable batteries.

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## WHAT IS IT?

Water and other liquids vary widely in their color and clarity. Some liquids, such as bottled water, are clear, while others, such as heavily polluted industrial waste, are murky and cloudy. This murkiness is called turbidity.

Turbidity is caused by fine particles suspended in the water which cause light to scatter rather than traveling in a straight line through the water. Clay, silt, plankton and other microorganisms are all examples of particulate which cause turbidity.

Many of the causes of turbidity are not necessarily harmful to human health, but turbidity can be a sign of another, more serious problem. For instance, cloudy pool water may not be dangerous to the swimmer, but it could indicate the presence of excess carbonates, which may damage the pool itself. Experienced wastewater plant operators use this idea every day. Generally, as the pollutant level of water decreases, the turbidity decreases. The EPA's Surface Water Treatment requirements state that finished water has turbidity levels below 1 NTU.

Over time, turbidity measurements can be used to determine if the pollution level of a lake or other water body has changed. Biologists and others monitoring the health of a specific lake will track the turbidity level over time to see if runoff from construction, agriculture, or other man-made changes is polluting the water. Likewise, a lower turbidity level may indicate a decrease in pollution.

## HOW IS IT MEASURED?

Turbidity can be measured in many ways. Traditionally, the Jackson Candle was used to measure turbidity, and results were expressed as Jackson Turbidity Units (JTU). In lakes and other deep waters, a Secchi Disk is commonly used to measure the turbidity. However, neither of these methods can accurately measure low turbidities, such as those encountered at a wastewater plant, so a turbidimeter must be used.

One type of turbidimeter is the nephelometer, which determines the turbidity level by measuring the amount of light scattered 90° by the suspended particles. A light of known strength is beamed through the solution, where particles will cause the light to scatter. The intensity of this scattered light is measured by sensors located on the sides of the chamber. The meter converts these measurements to a reading, which is displayed. Nephelometers give readings in Nephelometric Turbidity Units (NTU).

Since the nephelometer measures the amount of light which is scattered by the turbid solution, it is important that no stray light interfere with the test. For this reason many turbidimeters, including the Model 2008, include a cap to cover the sample chamber during testing. Additionally, scratches, fingerprints, and water droplets on the outside of the sample tubes can cause additional light scatter, leading to inaccurate readings.

In addition to scratches and water droplets, the actual glassware itself is very important in turbidity readings, and differences between tubes and their orientation in the chamber can cause differences in test results. To assure the tubes are always placed in the chamber in the same orientation, the cap can be marked in some way, such as with a piece of tape. If this cap is always used with the same tube, by orienting the tape in the same way in the chamber each time, more accurate results can be obtained.

The Model 2008 is a versatile turbidimeter. It offers a choice of two ranges, which measure from 0 to 19.99 NTU or 0 to 199.9 NTU, allowing it to be used in treated water, natural water, or wastewater. The meter is precalibrated prior to leaving LaMotte's manufacturing facility, but it should be standardized prior to use.

<i>ANGE</i>	0-19.99 NTU 0-199.9 NTU
<b>ACCURACY</b>	± 2% of reading or 0.05 NTU, whichever is greater, referenced to LaMotte AMCO® standards
<b>DISPLAY</b>	0.5" LCD
<b>WARM-UP TIME</b>	<2 seconds
<b>PHOTODETECTOR</b>	Silicon photodiode, aligned 90° to the incident light path
<b>LAMP</b>	Tungsten, lens-end long life, operated at a color temperature of 2230° K
<b>SAMPLE</b>	Distance traversed by incident light and scattered light within tube is 2.5 cm
<b>LAMP LIFE</b>	45,000 hours
<b>RANGE SELECTOR</b>	4-position: Charge only, Off, 0-20 NTU, 0-200 NTU
<b>POWER SOURCE</b>	Ni-Cad rechargeable batteries, not user replaceable
<b>SIZE</b>	19 cm x 7 cm x 14 cm 7.5" x 2¾" x 5⅜"
<b>WEIGHT</b>	1.1 Kg 2.4 lbs.

## REPLACEMENT PARTS & ACCESSORIES

5115PT-J	Deionized Water, 100 mL
1793	AMCO® Turbidity Standard, 0.5 NTU
1794	AMCO® Turbidity Standard, 5.0 NTU
1795	AMCO® Turbidity Standard, 20.0 NTU
1796	AMCO® Turbidity Standard, 60.0 NTU
1797	AMCO® Turbidity Standard, 100.0 NTU
1798	AMCO® Turbidity Standard, 40.0 NTU
1744	AC Adapter, 9 Volt
0273	Turbidity tubes, set of 6
0943	Syringe
0598	Filter holder
1103-6	Member filters, 0.45 micron, pkg of 6

# CALIBRATING

The Model 2008 has been calibrated at the factory using a primary standard manufactured by Advanced Polymer Systems, Inc., which is a suspension of uniformly sized plastic "microspheres." These AMCO® standards require no preparation, and are stable for longer periods of time than formazin. However, with proper preparation techniques, formazin standards should be equivalent to the AMCO® standards, and can be used as primary standards for meter calibration. For proper procedures, consult the current edition of *Standard Methods for the Examination of Water and Wastewater*.

## AMCO® TURBIDITY STANDARDS

Two AMCO® turbidity standards are supplied with the Model 2008; additional standards are available from LaMotte Company. Only use LaMotte AMCO® standards with the Model 2008. These standards are manufactured exclusively for LaMotte and are guaranteed to be accurate to within ± 1%, if the following procedures are observed:

1. Once the seal on the bottle is broken, the standard is good for 9 months, and must be stored between 10° and 40° C. The standards are good indefinitely prior to opening if stored under the same conditions.
2. Never put any unused standard or other possible contaminant into the bottle.
3. Do not open the standards in a dusty environment, and guard against dust and other contaminants entering the bottle while opened.
4. Rinse sample tube with standard before filling with standard to be used.
5. Cap the sample tube and standard bottle immediately after filling tube with standard.

## TURBIDITY TUBES

---

To assure accurate readings the tubes supplied with the Model 2008 should be paired with marked caps. Mark each cap with a piece of tape, and pair with a tube. When the tubes are inserted into the chamber, the tape should always be oriented the same way, for instance, the tape should always point toward the operator. If greater accuracy is required, for instance for Surface Water requirements, the tubes supplied with the Model 2008 should be calibrated. Fill all the tubes with the same turbidity standard, preferably one at the higher end of the testing range. Insert each tube into the meter, and record the reading. This data will indicate the correction factor which should be used when comparing results in different tubes.

## THE MODEL 2008 TURBIDIMETER

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1. Select the AMCO<sup>®</sup> standard closest to the value of the sample.

**NOTE:** Only use LaMotte specific AMCO<sup>®</sup> turbidity standards with the Model 2008. Contact LaMotte for replacement standards.

2. Switch the selection knob to the proper range (0 - 20 or 0 - 200 NTU).
3. Fill turbidity tube with standard. Cap with paired, marked cap. Wipe tube with a lint-free tissue.
4. Insert tube into chamber. Cap chamber.

**NOTE:** The green LED will light to indicate tube is fully inserted, and the meter is working.

5. Adjust STANDARDIZE knob until display reads value of standard. The Model 2008 is now calibrated and ready for use.

## TESTING

1. Fill a clean container with at least 50 mL of sample water. Set container aside to allow sample to equilibrate to air temperature, and to let gasses escape.

**NOTE:** Do not let dust or other airborne contaminants contact sample.

2. Rinse an empty turbidity tube with sample. Fill turbidity tube to neck with sample water.

**NOTE:** Pour sample down the side of tube to avoid creating air bubbles.

3. Cap with paired, marked cap. Wipe tube with a lint free tissue.

4. Insert tube into chamber. Cap chamber. Select appropriate range on selection knob. As soon as reading stabilizes, record reading as NTU.

**NOTE:** The green LED will light to indicate tube is fully inserted, and the meter is working.

5. If the sample has a turbidity reading of greater than 200 NTU, the sample must be diluted with turbidity-free water before being tested. Multiply result by the appropriate factor.

## PREPARING TURBIDITY-FREE WATER

If the sample turbidity is higher than 200 NTU, it must be diluted with turbidity-free water, and retested. It is very important that no foreign matter be introduced into the water. Water prepared using this procedure can be stored in a clean glass jar, with a cap, in a dark area at room temperature, and used as required. Always check the water for particles or other foreign matter before using.

1. Unscrew the filter holder (0598), and place a white membrane filter (1103) on the screen inside. Make sure the membrane is centered on the screen and covers the entire surface. Replace top of filter holder.
2. Remove the plunger from the syringe and attach filter holder to bottom of syringe (0943).
3. Fill syringe with deionized or distilled water. Insert plunger and, exerting pressure, slowly force water through filter. Collect water in a suitable clear, glass storage container.
4. Remove filter holder from syringe, then remove plunger from barrel.
5. Replace filter holder, and repeat Steps 3 and 4 until desired amount of turbidity-free water has been collected.

**NOTE:** Periodically examine the membrane filter to assure no holes or cracks are present.

## DILUTING THE SAMPLE

If the sample has a reading greater than 200 NTU, it must be diluted with turbidity-free deionized water to bring the reading within the range of the Model 2008.

The following table gives quick reference guidelines on dilutions of various proportions. All dilutions are based on a 25 mL volume. Graduated pipets should be used for all dilutions.

SIZE OF SAMPLE	TURBIDITY-FREE WATER TO BRING VOLUME TO 25 mL	MULTIPLICATION FACTOR
25 mL	0 mL	1
12.5 mL	12.5 mL	2
2.5 mL	22.5 mL	10

**EXAMPLE:** Measure 12.5 mL of sample water into a graduated cylinder. Add turbidity-free water until the cylinder is filled to the 25 mL line. The sample has been diluted by one-half, and the dilution factor is therefore 2. Perform the test procedure, then multiply the reading from the display by 2 to obtain the test result.

## RECHARGING THE BATTERY

The Model 2008 is supplied with Ni-Cad rechargeable batteries. These batteries can be recharged, but can only be replaced by LaMotte personnel. **Attempting to replace the batteries yourself will void the warranty.** A small indicator will appear on the left side of the display when the batteries need to be recharged.

**NOTE:** The Model 2008 can continue to make measurements while the battery is recharging. See Testing on page 9 for procedures.

1. Connect AC adapter to the Model 2008.
2. Set selection knob to CHARGE BATTERY. The red LED will light, indicating the batteries are recharging.

**NOTE:** Measurements can be made while the batteries are recharging.

3. The batteries will be completely recharged in approximately 4.5 hours. The red LED will extinguish when the batteries are recharged.

If there is no display when the selector knob is switched to 0-20 or 0-200, the battery has no charge. Plug in the adapter, switch the selector knob to "OFF", and leave the meter plugged in overnight. The battery can be recharged using the above procedure.

## REPLACING THE BATTERIES

When the batteries are no longer able to hold a charge, return the instrument to LaMotte Company for new batteries. Replacing the batteries yourself voids the meter warranty.

## REPLACING THE LAMP

The tungsten lamp included with the Model 2008 will last approximately 45,000 hours. If you suspect the lamp is dimming, insert a clean empty sample tube into the chamber. If the display is unstable, the lamp needs to be replaced. Call LaMotte Company for a return authorization number to have the lamp replaced.

The Model 2008 was factory calibrated using AMCO® standards. If formazin or other standards are used, or the front panel calibration procedure does not supply sufficient range, an internal calibration procedure should be used.

**NOTE:** Adjusting any internal components other than those specified will void the meter warranty.

1. Select two standards to use during the calibration procedure. The lowest and highest NTU standards should be chosen. (Ex. 0.5 and 5.0)
2. Make sure all glassware is clean and scratch-free. Wipe tubes with a lint free tissue to remove all fingerprints.
3. Set the selection knob to OFF.
4. Remove the four screws from the base of the turbidimeter. Holding the meter face down, carefully lift the back off the meter.

**NOTE:** The back and faceplate are connected by a short ribbon-cable. Do not disconnect this cable.

5. Set the meter in an upright, operating position on a flat surface.
6. Set the STANDARDIZE knob to the 12 o'clock position.
7. Set the selection knob to the proper range for the chosen standards (0 - 20 NTU or 0 - 200 NTU).
8. Insert the tube containing the low standard into the chamber. Place cap on chamber. Use a screwdriver to adjust the zero trim pot until the display reads the proper NTU value.

**CAUTION:** Only adjust the zero trim pot. Do not adjust other potentiometers. See diagram on following page to determine position of zero trim pot.

**NOTE:** Rapid hand movements near the circuit board may cause readings to fluctuate. Allow readings to stabilize before continuing.

9. Insert the tube containing the high standard into the chamber. Place cap on chamber. Use a screwdriver to adjust the slope trim pot until the display reads the proper NTU value.

**CAUTION:** Only adjust the slope trim pot. Do not adjust other potentiometers. See diagram below to determine position of slope trim pot.

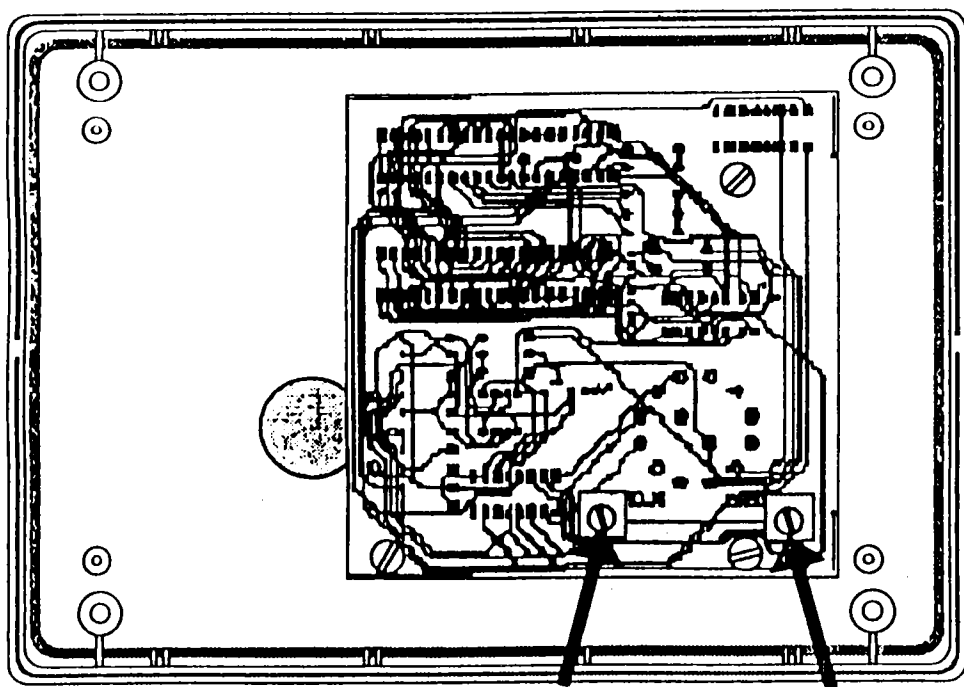
**NOTE:** Rapid hand movements near the circuit board may cause readings to fluctuate. Allow readings to stabilize before continuing.

10. Repeat Steps 8 and 9 until both the low and high standard values are correctly displayed.

**NOTE:** Use the orientation mark on the caps to assure the tubes are being placed in the meter the same way each time.

11. Reattach faceplate to back. The Model 2008 is now calibrated and ready to use.

### Inside View of Front Panel



Slope Adjust      Zero Adjust

## WARRANTY INFORMATION

### REPAIRS

If it is necessary to return the instrument for repair, contact LaMotte Company at 1-800-344-3100 for a return authorization number.

### INSTRUMENT GUARANTEE

This instrument is guaranteed to be free of defects in material and workmanship for one year from date of original purchase. If, in that time, it is found to be defective, it will be repaired without charge, except for transportation expenses. This guarantee does not cover the batteries.

This guarantee is void under the following circumstances:

- operator's negligence
- improper application
- unauthorized servicing

### LIMITS OF LIABILITY

Under no circumstances shall LaMotte Company be liable for loss of life, profits, or other damages incurred through the use or misuse of their products.

### PACKAGING AND DELIVERY

Experienced packaging personnel at LaMotte Company assure adequate protection against normal hazards encountered during shipping. After the product leaves the manufacturer, all responsibility for its safe delivery is assured by the transporter. Damage claims must be filed immediately with the transporter to receive compensation for damaged goods.

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